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ABSTRACT

This guide contains instructor's materials for teaching a secondary agricultural construction course consisting of instructional units on oxy-gas and other cutting and welding processes (10 lessons), woodworking (6 lessons), metals (10 lessons), and finishing (4 lessons). The materials for each unit include student objectives, a list of competencies from which the objectives were derived, suggestions for motivating students to study the unit, lists of references for the student and teacher, a competency profile on which student performance can be recorded, and the lessons. The lessons typically contain study questions; student handouts, including job sheets and other work sheets; questions to be used to evaluate student performance; teaching procedures, including some content material; and answers to evaluation questions. (CML)

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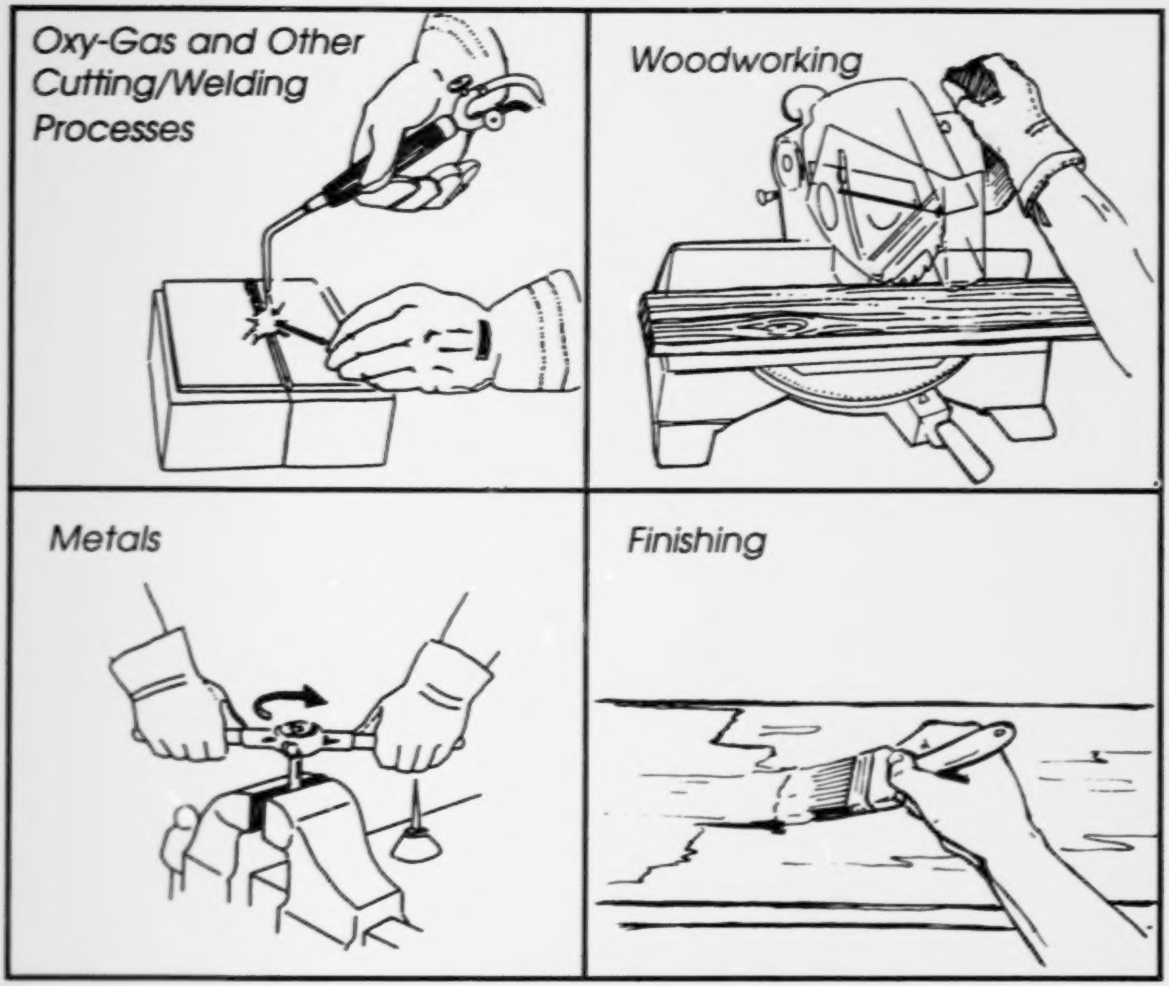
10-7142-I

Agricultural Construction

Volume II


Oxy-Gas and Other Cutting/Welding Processes
Woodworking
Metals
Finishing

Instructor's Guide

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Instructor's Guide

AGRICULTURAL CONSTRUCTION (Volume II)

Oxy-Gas and Other Cutting/Welding Processes
Woodworking
Metals
Finishing

Writers:
Myron Admire and
Gary Maricle
Instructional Materials Laboratory
University of Missouri-Columbia

Consulting Editor:
Leon Schumacher
Agricultural Education
University of Missouri-Columbia

Veronica Feilner, Editor
Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, Missouri 65211

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Myron Admire and Gary Maricle
Graduate Research Assistants
Instructional Materials Laboratory
University of Missouri-Columbia

Leon Schumacher, Assistant Professor
Agricultural Education
University of Missouri-Columbia

FOREWORD

The development of a curriculum guide for Agricultural Construction was suggested by the MVATA Teaching Aids Committee. The Agricultural Construction Advisory Committee suggested the topics to be discussed and reviewed the materials. The Agricultural Construction curriculum has been printed in two volumes. Volume I, which was printed earlier, contains units on Arc Welding and Project Construction.

This volume, Volume II, contains units on Oxy-Gas and Other Cutting/Welding Processes, Woodworking, Metals, and Finishing. Student handouts, demonstration sheets, assignment sheets, and job sheets have been developed as needed to supplement existing references for each unit. The "Table of Contents" for Volume II contains a detailed listing of lessons. The "Contents" section in each unit contains objectives, competencies, references, and a competency profile. Each unit contains a "Getting Ready for this Unit" section which suggests tips for preparing to teach the unit.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, Dr. Frank Drake, Director of Vocational Education, applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed components to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of each unit, as well as being incorporated within each lesson. A competency profile has also been provided in each unit for convenient record keeping.

Bob R. Stewart, Professor and
Coordinator
Agricultural Education
University of Missouri-Columbia

Terry Heiman, Director
Agricultural Education
Department of Elementary and
Secondary Education

AGRICULTURAL CONSTRUCTION (Volume II)

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UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

GETTING READY FOR THIS UNIT

Welding Skills, by Giachino and Weeks, is the suggested student reference for this unit. Handouts, demonstration sheets, and job sheets have been developed when necessary to supplement the reference. Some of the skills needed for this unit are included in the Agricultural Science II core curriculum. Since the information is not presented again, it should be reviewed before beginning this unit.

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OBJECTIVES

1. The student will be able to list the safety procedures required for using oxy-acetylene equipment.

2. The student will be able to light, adjust, and shutdown the torch.

3. The student will be able to select the proper tip for the weld to be performed.

4. The student will be able to oxy-acetylene weld in the flat, horizontal, vertical, and overhead positions.

5. The student will be able to perform a hardsurfacing operation with oxy-acetylene.

6. The student will be able to weld cast iron.

7. The student will be able to perform a braze welding operation.

8. The student will be able to properly cut metal with the oxy-gas cutting unit.

9. The student will be able to cut a piece of metal using arc-air and plasma-arc cutting processes.

10. The student will be able to properly cut metal using the motorized torch.

NOTE: Percent of accuracy should be set by instructors to reflect passing grades within their school systems.

COMPETENCIES

1. List the safety procedures required for using oxy-acetylene equipment.

2. Perform in order the complete procedure for lighting, adjusting the flame, and shutdown of the torch.

3. Select appropriate tip for the job to be performed.

4. Weld in all positions with oxy-gas welder.
    a. Weld in flat position.
    b. Weld in horizontal position.
    c. Weld in vertical position.
    d. Weld in overhead position.

5. Perform a hardsurfacing operation.

6. Weld cast iron using rod and flux.

7. Perform a braze weld operation.

8. Perform cutting with oxy-gas.

9. Perform cutting with arc-air.

10. Cut using the motorized torch.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Ask students to list uses of oxy-acetylene cutting and welding. What types of jobs may be performed with the torch? Discuss the use of air-arc, plasma-arc, and motorized torches in industry.

2. Review the parts of the torch with students. Have students demonstrate the proper lighting and shutting down of the torch. Provide a reward to the first student to follow the exact procedures for using the torch.

3. At the beginning of this unit, establish levels of proficiency for the students to achieve in using the oxy-acetylene torch and other metal cutting tools. Discuss minimum requirements for each level that must be met before the student can move to the next level. At the end of the unit, give certificates to indicate the level of achievement reached. Present awards (e.g., most improved, best weld, best welder) to students at an FFA meeting or banquet.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit. Evaluate students' performance for each metal cutting operation.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background information acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. **Student References**

    a) Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985

    b) Agricultural Construction Volume II (Student Handouts). University of Missouri-Columbia: Instructional Materials Laboratory, 1989.

2. **Teacher References**

    a) "Agricultural Mechanics I," Agricultural Science I Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

    b) "Agricultural Mechanics II," Agricultural Science II Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

    c) Baird, Ronald J. Oxy-Acetylene Welding - Basic Fundamentals. South Holland, IL: The Goodheart-Willcox Company, Inc., 1980.

d) Cooper, Elmer L. Agricultural Mechanics: Fundamentals and Applications. Albany, NY: Delmar Publishers, Inc., 1987.

e) Day, Roger; Eric Rygaard. Welding. University of Missouri-Columbia: Instructional Materials Laboratory, 1988.

f) Fortney, Clarence and Mike Gregory. Oxy-Acetylene Welding and Cutting. Stillwater, OK: MAVCC, Inc., 1984.

g) Griffin, Ivan H., et al. Welding Processes. 3rd edition. Albany, NY: Delmar Publishers, Inc., 1984.

h) Jeffus, Larry and Harold V. Johnson. Welding Principles and Applications. 2nd edition. Albany, NY: Delmar Publishers, Inc., 1988.

i) Instructor's Manual for a Basic Course: Oxy-acetylene Brazing, Cutting, and Welding. Minneapolis, MN: Smith Equipment Division of Tescom Corporation, 1967.

j) Phillips, Arthur L. ed. American Welding Society. Welding Handbook - Fundamentals of Welding. 6th ed. NY: AMS - United Engineering Center, 1968.

k) The Oxy-Acetylene Handbook, 3rd ed. New York: Union Carbide Corporation-Linde Division, 1976.

Agricultural Construction
Unit II - Oxy-Gas and Other Cutting/Welding Processes

Class/Section: ______________________

udents:

	List the safety procedures required for using oxy-acetylene equipment	Perform in order the complete procedure for lighting, adjusting the flame and shutdown of the torch	Weld in all positions with oxy-gas welder:	Weld in flat position	Weld in horizontal position	Weld in vertical position	Weld in overhead position	Perform a hardsurfacing operation	Weld cast iron using rod and flux	Perform a braze weld operation	Perform cutting with oxy-gas	Perform cutting with arc-air	Cut using the motorized torch	Select appropriate tip for the job to be performed		

Agricultural Construction
Unit II - Oxy-Gas and Other Cutting/Welding Processes
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale: 3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N	**Oxy-Gas and Other Cutting/Welding Processes**
	▨	▨	▨	1. List the safety procedures required for using oxy-acetylene equipment
	▨	▨	▨	2. Perform in order the complete procedure for lighting, adjusting the flame and shutdown of the torch
▨	▨	▨	▨	3. Weld in all positions with oxy-gas welder
				a. Weld in flat position
				b. Weld in horizontal position
				c. Weld in vertical position
				d. Weld in overhead position
				4. Perform a hardsurfacing operation
				5. Weld cast iron using rod and flux
				6. Perform a braze weld operation
				7. Perform cutting with oxy-gas
				8. Perform cutting with arc-air
				9. Cut using the motorized torch
				10. Select appropriate tip for the job to be performed
				Other (specify)
				______________________
				______________________

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 1: Safety Procedures for Oxy-Acetylene Equipment

Objective: The student will be able to list the safety procedures required for using oxy-acetylene equipment.

Study Questions

1. **What precautions should be taken when handling oxygen and acetylene cylinders?**
2. **What precautions should be taken when using oxygen and acetylene?**
3. **What procedures are necessary for proper use of regulators?**
4. **What procedures are necessary for proper handling of hoses?**
5. **How is oxy-acetylene equipment tested for leaks?**
6. **What are the proper safety precautions for care of the torch and welding tips?**
7. **When should clear goggles be worn when using oxy-acetylene equipment?**
8. **How can harmful light rays from oxy-acetylene welding be avoided?**
9. **What type of clothing and footwear should be worn while welding?**
10. **How can burns be avoided during oxy-acetylene welding?**
11. **What steps should be taken in the case of an injury in the shop area?**

Reference

1. Giachino, Joseph W., William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 1: Safety Procedures for Oxy-Acetylene Equipment

TEACHING PROCEDURES

A. Review

Introduce the unit. Review Agricultural Science II Core Curriculum (Oxy-Acetylene Welding, Lesson 1).

B. Motivation

Handling highly pressurized gases of up to 2,200 pounds per square inch (psi) must be done properly and cautiously to avoid injury to persons or damage to equipment. Explain to students how pressurized tanks can be powerful. Emphasize the need for safety and what can happen if wearing improper eye wear, clothing, and footwear. Show available films and filmstrips concerning oxy-acetylene welding safety.

C. Assignment

D. Supervised study

E. Discussion

1. Cylinders used in oxy-acetylene welding are highly pressurized. Cylinders that are mishandled can result in serious injuries to students. Discuss with students what things must be considered when handling oxygen and acetylene cylinders.

   What precautions should be taken when handling oxygen and acetylene cylinders?

   a) Never lift cylinders by the cap.
   b) Do not lay cylinders in a horizontal position.
   c) Keep grease and oil away from cylinder valves.
   d) Do not expose cylinders to excessive heat or torch sparks.
   e) Never move cylinders by dragging, sliding, or rolling.
   f) Avoid striking cylinders with a foreign object.
   g) Be sure cylinder valves are shut off before moving.
   h) Never try to repair or force a cylinder valve open. Notify the supplier of any problems.
   i) Keep valves closed on empty cylinders.
   j) Keep unused cylinders covered with valve protector caps.
   k) Cylinders should be stored at least 20 feet from other combustible materials.
   l) Oxygen cylinders should be separated from acetylene cylinders by a 5-foot high concrete wall or stored in a separate area.
   m) Regulators should be removed and valve protector caps put on before moving cylinders without a truck.
   n) Write "EMPTY" on empty cylinders.

2. Special care should be taken when using oxygen and acetylene to avoid creating dangerous working conditions. Ask students to list precautions that should be followed when using oxygen and acetylene.

What precautions should be taken when using oxygen and acetylene?

a) Secure oxygen and acetylene cylinders in an upright position.
b) Do not use oxygen to blow dust off of clothing or equipment.
c) Do not use oxygen or acetylene without proper ventilation.
d) Always wear safety glasses (industrial quality eye protection which meet ANSI Z87.1 standards) when handling oxygen or acetylene.
e) Open the oxygen valve all the way to prevent leaking around the threads.
f) Open acetylene valve 1/2 turn so that it may be shut off quickly in an emergency.

3. Proper use of the regulator is important to ensure safety when working with oxy-acetylene equipment. Discuss with students the proper steps in operating a regulator.

What procedures are necessary for proper use of regulators?

a) Oxygen regulator fittings have right-hand threads and acetylene regulator fittings have left-hand threads to prevent connecting them to the wrong cylinders.
b) To avoid damaging regulators, do not leave them lying on the floor.
c) Be sure adjusting screw is released before opening the cylinder valve.
d) Never use oil on regulators.
e) Use soap or glycerine to lubricate the adjusting screw.
f) Do not interchange regulators.
g) Always have faulty regulators repaired immediately by qualified persons. (Do not try to repair or fix them yourself.)
h) Open cylinder valves slowly to avoid damage to the regulators.
i) Always keep tight connections on regulators and hoses to avoid leaks.

4. Hoses that are not properly connected or maintained can create a hazardous environment for oxy-acetylene welding. Ask the students to describe the correct way to handle and maintain hoses.

What procedures are necessary for proper handling of hoses?

a) Check all connections for proper tightness.
b) Avoid dragging or pulling the hoses.
c) Protect hoses from being stepped on or having things dropped on them.
d) Roll hose up when not in use.
e) Use regular hose binders or clamps when connecting hoses.
f) Use standard brass splicing nipples to splice hoses together.
g) Do not repair leaking hose with tape.
h) Bleed the oxygen and acetylene from hoses when not in use to avoid damaging the hoses.
i) Check for leaks when the hoses are attached.
j) Never cut or weld toward hoses.

5. Check hoses for leaks periodically and anytime new connections have been made. Ask the students to describe the correct way to check for leaks.

How is oxy-acetylene equipment tested for leaks?

a) Test connections using a clean paint brush and soapy water.
b) Test equipment immediately after making new connections.

c) Test equipment periodically for leaks.
d) Submerge hoses in water and watch for bubbles.

6. Welding tips will fail to provide the correct flame to the weld area if not cared for properly. Ask students the proper way to handle the torch and welding tips.

What are the proper safety precautions for care of the torch and welding tips?

a) When not in use, always hang up the torch securely so it will not fall.
b) Never drop or strike the torch.
c) Adjust packing nuts to keep needle valves turning properly.
d) Use a torch wrench, not pliers, to replace a welding tip.
e) Never mount a tip while the torch is hot.
f) Keep the welding tip clean at all times.
g) Use only the proper size of tip cleaner to clean tips.
h) Brush the end of tip with fine sandpaper to keep it free of slag.

7. Clear goggles are an important safety precaution, even when working with oxy-acetylene. A face shield can be used instead of clear goggles. Ask the students when they should wear clear goggles over their safety glasses.

When should clear goggles be worn when using oxy-acetylene equipment?

a) Grinding
b) Filing
c) Wire brushing

8. The light produced from the oxy-acetylene process is bright enough to be hazardous to the unprotected eye. Ask students what they can do to avoid harmful light rays resulting from oxy-acetylene welding.

How can harmful light rays from oxy-acetylene welding be avoided?

a) Always wear welding goggles or face shield with at least a No. 4 shade lens.
b) Never look at the flame with an unprotected eye.
c) Always check the goggles or face shield for cracks before using.

9. The sparks produced when using oxy-acetylene equipment make it necessary to thoroughly protect the body. Ask the students to list the protective clothing and footwear necessary to wear when oxy-acetylene welding.

What type of clothing and footwear should be worn while welding?

a) Wear an apron, shop coat or coveralls.
b) Do not wear sweaters or other flammable synthetic clothing.
c) Wear a welding cap when welding out of position.
d) Wear a pair of lightweight, gauntlet-style gloves.
e) Wear leather, hard soled shoes.
f) Pants should be cuffless or have cuffs turned down.
g) Frayed or torn clothing should not be worn.
h) Remove jewelry.
i) Place long hair in a hair net.

10. Oxy-acetylene equipment uses fire and heat; therefore, increasing the chance of someone getting burned. Discuss with students how burns can be avoided.

How can burns be avoided during oxy-acetylene welding?

a) Use tongs or pliers to handle hot metal.
b) Never point the torch toward another person when lighting it.
c) Never hand another person a hot piece of metal or a hot torch.
d) The word "HOT" should be written on metal that cannot be moved to a storage area to warn other students not to touch it.
e) Keep your hands away from the flame.

11. The appropriate action should be taken in the case of an emergency. Discuss with students the immediate dangers that exist in the oxy-acetylene welding area. Discuss appropriate steps that should be taken in case of an injury. See Appendix A in Volume I for more information.

What steps should be taken in the case of an injury in the shop area?

a) Notify the instructor of the injury.
b) See the school nurse for treatment.
c) Seek medical attention, if necessary.

F. Other activities

1. Construct a bulletin board on oxy-acetylene welding safety.

2. Construct a display of equipment used in oxy-acetylene welding for science fair or job fair.

3. Have students prepare written or oral reports on oxy-acetylene welding safety.

4. Check with your local welding equipment/supplies distributor for available safety films or videos.

G. Conclusion

Because oxy-acetylene welding involves the use of highly pressurized gases and flames, a safe, clean work area must be provided. Students must use the proper protective clothing and equipment. Smoke and fumes created during the welding process make ventilation of the work area necessary. Do not weld around any combustible or flammable materials or containers. Care must be taken to show proper concern for others in the oxy-acetylene welding area or station.

H. Competency

List the safety procedures required for using oxy-acetylene equipment.

I. Answers to Evaluation

1. b
2. d
3. a
4. b
5. c
6. d
7. c
8. b
9. c
10. a

Name ____________________

Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. When handling oxygen and acetylene cylinders, which of the following is not appropriate?

   a. Avoid striking cylinders with other objects.
   b. Keep valves open on all empty cylinders.
   c. Do not lay cylinders in a horizontal position.
   d. Never lift a cylinders by the cap.
   e. Do not expose cylinders to heat or sparks.

2. Cylinders should be stored at least how far from other combustible materials?

   a. 5 ft.
   b. 10 ft.
   c. 15 ft.
   d. 20 ft.
   e. 25 ft.

3. Test for leaks by using ______________.

   a. A clean brush and soapy water
   b. Used oil
   c. A match
   d. Bare hands
   e. Your ears to listen closely

4. Which of the following should not be done when handling the torch?

   a. Wait for torch to cool before mounting new tip
   b. Use pliers to tighten the welding tip
   c. Suspend the torch so it won't fall
   d. Use only a tip cleaner to clean tips
   e. Keep needle valves properly adjusted

5. You should always wear goggles or a face shield with at least a _________ shade of lens.

   a. No. 2
   b. No. 3
   c. No. 4
   d. No. 5
   e. No. 6

6. Which of the following types of clothing is acceptable for safe oxy-acetylene welding?

   a. Polyester clothing
   b. Coveralls with frayed holes
   c. Tee shirt
   d. Apron or shop coat
   e. Sweatshirt or sweater

7. Handle hot pieces of metal with _______________.

   a. Your bare hands
   b. Cotton gloves
   c. Pliers
   d. Rubber gloves
   e. Gauntlet-style gloves

Match the action on the right with the proper statement on the left.

8. _____ Handling hoses — a. Contact instructor

9. _____ Grinding or wire brushing — b. Avoid dragging or pulling

10. _____ In case of injury — c. Wear clear goggles or face shield

Lesson 2: Lighting, Adjusting, and Shutting Down the Torch

Objective: The student will be able to light, adjust, and shutdown the torch.

Study Questions

1. **How is the oxy-acetylene welding outfit assembled?**
2. **What is the proper procedure for lighting the torch?**
3. **How is the flame adjusted?**
4. **How is the torch properly shut down?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   - a) HO 2.1: Adjusting the Torch Flame
3. Demonstration Sheet
   - a) DS 2.1: Lighting, Adjusting, and Shutting Down the Torch
4. Job Sheet
   - a) JS 2.1: Lighting, Adjusting, and Shutting Down the Torch

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 2: Lighting, Adjusting, and Shutting Down the Torch

TEACHING PROCEDURES

A. Review

Review Lesson 1 on safety procedures for oxy-acetylene equipment.

B. Motivation

Setting up and using the oxy-acetylene assembly can be potentially dangerous if not done properly. One step done improperly or at the wrong time could result in a major explosion harming several individuals as well as destroying the laboratory facilities. Have someone from a supply or equipment company speak to the students regarding proper lighting, adjusting, and shutting down of the torch.

C. Assignment

D. Supervised study

E. Discussion

1. Proper assembly of oxy-acetylene equipment is necessary for safe use while welding. Discuss with students how the oxy-acetylene set-up is assembled.

How is the oxy-acetylene welding outfit assembled?

a) Chain cylinders in an upright position.
b) Crack the cylinder valves to remove dust.
c) Wipe fittings with a clean soft cloth.
d) Attach the regulators to the cylinders.
e) Use a designated cylinder wrench to connect the hoses to the regulators.
f) Use a designated cylinder wrench to connect the check valves and hoses to the torch.
g) Insert a tip into the torch body and hand tighten.
h) Test the connections for leaks.

2. A certain procedure should be followed when lighting the torch to provide for safety of the student. Discuss the correct procedure for lighting the torch.

What is the proper procedure for lighting the torch?

a) Loosen the adjusting screws on the regulator and close the needle valve on the torch.
b) Slowly open the oxygen cylinder valve all the way.
c) Slowly open acetylene cylinder valve 1/2 turn.
d) Open the acetylene needle valve on torch 1/4 to 1/2 turn.
e) Adjust the acetylene pressure to the appropriate psi setting for the tip selected with the adjusting screw on the regulator and close the needle valve.
f) Open oxygen needle valve on the torch.

g) Adjust oxygen pressure to the appropriate psi setting for the tip selected with the adjusting screw on the regulator and close the needle valve.
h) Point the torch away from yourself, other students, and the cylinders.
i) Open acetylene needle valve 1/2 turn.
j) Light the acetylene with a sparklighter. NEVER use a match or cigarette lighter!
k) Open the acetylene valve until the thick smoke disappears.

3. Discuss the types of flames that are used in oxy-acetylene welding. Distribute HO 2.1 to illustrate the types of flames.

How is the flame adjusted?

a) Gradually open oxygen needle valve until neutral flame appears.
b) Adjust to make carburizing flame, then an oxidizing flame.
c) Return to the neutral flame.

4. Ask the students what steps should be followed when shutting off the torch. Even though there are two acceptable procedures for shutting down the torch, only one will be discussed here.

How is the torch properly shut down?

a) Close the acetylene needle valve.
b) Close the oxygen needle valve.
c) Close both cylinder valves.
d) Open the acetylene needle valve to drain pressure in hose and regulators; then close the needle valve.*
e) Open the oxygen needle valve to drain pressure in hose and regulators; then close the needle valve.*
f) Release acetylene regulator adjusting screw.
g) Release adjusting screw on oxygen regulator until it turns easily.
h) Wrap up the hose and torch and hang it properly.
i) Clean work bench and immediate area.

*Both working pressure gauges and cylinder pressure gauges should read 0 psi.

NOTE: The instructor should demonstrate proper procedure using DS 2.1. Have each student go through the procedures for lighting the flame under teacher supervision. Use JS 2.1.

F. Other activity

Ask questions about setting up and adjusting the torch. Let the first student who correctly answers the question ask the next question.

G. Conclusion

Setting up and using the oxy-acetylene assembly can be potentially dangerous; however, it can be safe if all steps are done in the proper order. Each student should be familiar with the proper order for lighting, adjusting, and shutting down the torch before using oxy-acetylene equipment.

H. Competency

Perform in order the complete procedure for lighting, adjusting the flame, and shutdown of the torch.

I. Answers to Evaluation

The evaluation for this lesson will be the successful completion of Job Sheet 2.1 on lighting, adjusting, and shutting down the oxy-acetylene torch. Use the evaluation page to record student progress. Job Sheet 2.1, for each student, should be kept on file in the instructor's office to document that the student has successfully met the competency for this lesson.

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ____________________

Lesson 2: Lighting, Adjusting, and Shutting Down the Torch Date ____________________

EVALUATION

Correctly demonstrate the following procedures with the instructor present.

1) Assemble the oxy-acetylene welding outfit.
    a) Areas to improve:
    b) Instructor's comments:

2) Properly light the torch.
    a) Areas to improve:
    b) Instructor's comments:

3) Adjust to a neutral flame.
    a) Areas to improve:
    b) Instructor's comments:

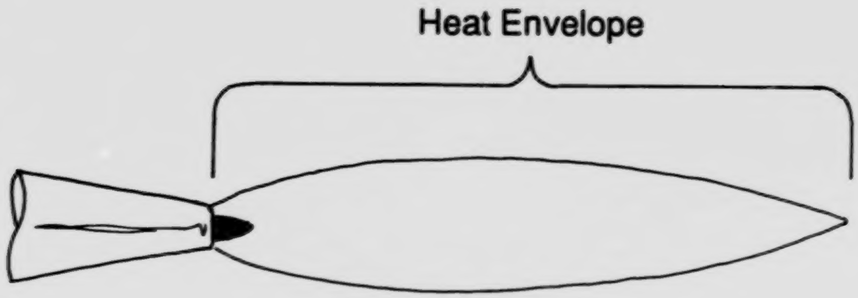
4) Properly shut down the torch.
    a) Areas to improve:
    b) Instructor's comments:

The student has correctly and accurately performed the above procedures for lighting, adjusting, and shutting down the torch, while following necessary safety procedures. Any suggestions listed in "areas to improve" have been satisfied.

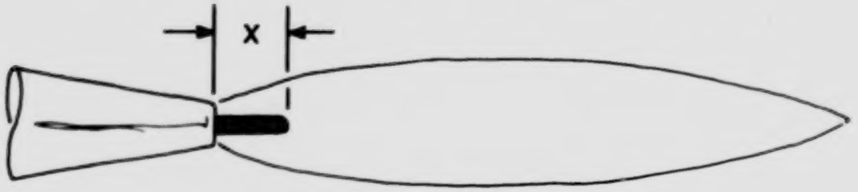
Instructor's signature ____________________

Student's signature ____________________

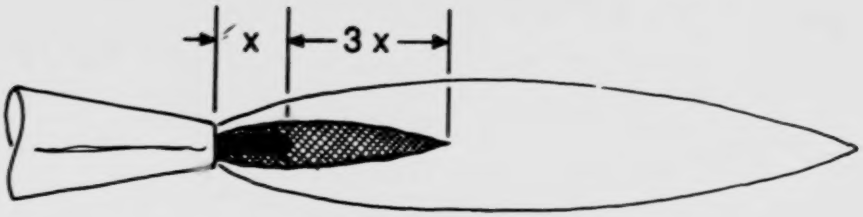
ADJUSTING THE TORCH FLAME


Heat Envelope

Oxidizing Flame



Neutral Flame



Carburizing Flame

Demonstration Sheet 2.1: Lighting, Adjusting, and Shutting Down the Torch

Objective: At the completion of this demonstration, the student will be ready to begin the JS 2.1 on lighting, adjusting, and shutting down the oxy-acetylene torch.

Tools and Equipment Needed:

1. Oxy-acetylene set-up
2. Sparklighter
3. Protective clothing
4. Safety glasses*
5. No. 3 welding tip
6. Welding goggles*

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Pre-lighting Procedure:

1. Remove flammable materials from the area and provide proper ventilation.

2. Put on protective clothing and welding goggles.

3. Slowly open the oxygen cylinder valve all the way.

4. Slowly open the acetylene cylinder valve 1/2 turn.

5. Open the acetylene needle valve on the torch 1/4 to 1/2 turn.

6. Adjust the acetylene pressure to the appropriate psi setting for the tip selected and the torch body used with the adjusting screw on the acetylene regulator.

   CAUTION: Never open an acetylene regulator valve above 15 psi because pressure beyond that point becomes unstable and could cause the regulator to explode.

7. Close the acetylene needle valve on the torch.

8. Open the oxygen needle valve on the torch.

9. Adjust the oxygen pressure to the appropriate psi setting for the tip selected and torch body used with the adjusting screw on the regulator.

10. Close the oxygen needle valve on torch.

Lighting the Torch:

1. Hold the torch away from yourself, other students, and the cylinders.

2. Open the acetylene needle valve 1/2 turn.

3. With the torch tip pointed downward, light the acetylene with a sparklighter.

4. Adjust the acetylene needle value so that a slight smoke is seen. Do not adjust the acetylene valve again unless you close the oxygen valve.

Adjusting the Flame:

1. Slowly open the oxygen needle valve on the torch to allow oxygen to mix with acetylene until a neutral flame appears.

Shutting Down the Torch:

1. Close the acetylene needle valve on the torch.
2. Close the oxygen needle valve on the torch.
3. Close the oxygen cylinder valve.
4. Close the acetylene cylinder valve.
5. Open the acetylene needle valve to drain the pressure in the hose.
6. Close the acetylene needle valve on the torch.
7. Loosen the acetylene adjusting screw until it turns easily.
8. Open the oxygen needle valve to drain the pressure in the hose.
9. Close the oxygen needle valve on the torch.
10. Loosen the oxygen regulator adjusting screw until it turns easily.
11. Place the hoses and torch back in the proper place.
12. Assign JS 2.1.

Job Sheet 2.1: Lighting, Adjusting, and Shutting Down the Torch

Objective: At the completion of this job sheet, the student will be able to light, adjust, and shut down the oxy-acetylene torch.

Tools and Equipment Needed:

1. Oxy-acetylene set-up
2. Sparklighter
3. Protective clothing
4. Safety glasses*
5. No. 3 welding tip
6. Welding goggles*

*CAUTION: Welding goggles and safety glasses must be worn by all students performing this job sheet. Safety practices should be followed at all times while in the shop area.

NOTE: The student should practice this job sheet several times. The instructor should be present to evaluate the final performance of this job sheet.

Pre-lighting Procedure:

1. Remove flammable materials from the area and provide proper ventilation.

2. Put on protective clothing and welding goggles.

3. Slowly open the oxygen cylinder valve all the way.

4. Slowly open the acetylene cylinder valve 1/2 turn.

5. Open the acetylene needle valve on the torch 1/4 to 1/2 turn.

6. Adjust the acetylene pressure to the appropriate psi setting for the tip selected and the torch body used with the adjusting screw on the acetylene regulator.

   CAUTION: Never open an acetylene regulator valve above 15 psi because pressure beyond that point becomes unstable and could cause the regulator to explode.

7. Close the acetylene needle valve on the torch.

8. Open the oxygen needle valve on the torch.

9. Adjust the oxygen pressure to the appropriate psi setting for the tip selected and the torch body used with the adjusting screw on the regulator.

10. Close the oxygen needle valve on torch.

Lighting the Torch:

1. Hold the torch away from yourself, other students, and the cylinders.

2. Open the acetylene needle valve 1/2 turn.

3. With the torch tip pointed downward, light the acetylene with a sparklighter.

4. Adjust the acetvlene needle value so that a slight smoke is seen. Do not adjust the acetylene valve again unless you close the oxygen valve.

Adjusting the Flame

1. Slowly open the oxygen needle valve on the torch to allow oxygen to mix with acetylene until a neutral flame appears.

2. Have the instructor check your flame and pressure settings.

Shutting Down the Torch:

1. Close the acetylene needle valve on the torch.

2. Close the oxygen needle valve on the torch.

3. Close the oxygen cylinder valve.

4. Close the acetylene cylinder valve.

5. Open the acetylene needle valve to drain the pressure in the hose.

6. Close the acetylene needle valve on the torch.

7. Loosen the acetylene adjusting screw until it turns easily.

8. Open the oxygen needle valve to drain the pressure in the hose.

9. Close the oxygen needle valve on the torch.

10. Loosen the oxygen regulator adjusting screw until it turns easily.

11. Place the hoses and torch back in the proper place.

12. Have the instructor check all valves and gauges for proper shut down.

13. Clean the work area.

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 3: Proper Tip Selection

Objective: The student will be able to select the proper tip for the weld to be performed.

Study Questions

1. **How are tips identified?**
2. **What is the range with which tips are identified?**
3. **What is the proper care for welding tips?**
4. **How is the proper welding tip selected?**
5. **How are special purpose tips used?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handouts
   - a) HO 3.1: Welding Tip Data
   - b) HO 3.2: Tip Cleaning Devices
   - c) HO 3.3: Special Purpose Tips

Lesson 3: Proper Tip Selection

TEACHING PROCEDURES

A. Review

Review the previous lesson on lighting, adjusting, and shutting down the torch.

B. Motivation

To make good welds, it is necessary to select the correct tip. Lay out all the different sizes of tips and various thicknesses of metal, and ask the students to choose the correct tip for each piece of metal. Show students the various tip cleaning tools and a tip which has not been taken care of properly. Ask them how they would go about restoring the tip.

C. Assignment

D. Supervised study

E. Discussion

1. Each manufacturing company has its own system of numbering the orifice size of each tip. Discuss with students how most tips are identified. Distribute HO 3.1 to the class to discuss tip size.

   How are tips identified?

   a) By tip size stamped on the torch end of each tip.
   b) By drill size listed in the manufacturer's information.
   c) By the diameter of the hole in the end of the tip.

2. There are various ranges for numbers identifying tips to be used. Each manufacturer might have their own system; however, there is one more common method used. Refer to HO 3.1 to match drill size with the tip size.

   What is the range with which tips are identified?

   a) Most common method has numbers that range from 000 to 15. The higher the number, the larger the tip diameter.
   b) Drill size identification method ranges from No. 1 to No. 80. A No. 1 drill measures .228 inch diameter while a No. 80 drill measures .0135 inch.

3. It is important to keep welding tips cleaned of carbon and slag so that the proper flame will be achieved. If the tip is not cleaned, it will overheat and become damaged. Discuss the need for tip cleaning and the methods listed below. Distribute HO 3.2 to illustrate the types of tip cleaning devices that are used.

   What is the proper care for welding tips?

   a) Installing the tip to prevent damage
      1) Use tips designed for the torch being used.

        2) Use a torch wrench to tighten the tip; never use pliers.
        3) Do not fit a cold tip to a hot torch.
    b) Cleaning the tip to remove carbon and slag
        1) Keep the tip end cleaned with a fine grade of sandpaper or a tip nip.
        2) Always use the correct size tip cleaner or tip drill.

4. The correct selection of the welding tip is vital to a good weld. The larger the hole in the tip, the more heat will be delivered to the weld area. Refer to HO 3.1 for selecting the correct tip.

    How is the proper welding tip selected?

    a) Based on the job to be performed
    b) Based on the thickness of the metal to be welded
    c) Based on the type of gas being used

5. There are certain processes which require a special tip in order to be done properly. Distribute HO 3.3 to illustrate the special tips used in agricultural construction.

    How are special purpose tips used?

    a) Oxy-acetylene heating tip (rosebud) - used for light preheating
    b) Oxygen-natural gas or propane heating tip - used for heating metal, silver brazing, and soft soldering
    c) Oxy-acetylene welding tip - used for welding, brazing, and silver brazing
    d) Oxygen-natural gas or propane brazing tip - used for brazing and silver brazing

F. Other activities

1. Prepare a chart that compares the manufacturer's tip number with a standard drill size for all welding tips in the shop.

2. Make a poster of procedures used to keep welding tips in good condition.

3. Have students inspect all torch tips in the shop and properly clean those in need.

G. Conclusion

All processes utilizing the various welding torch tips can only be accomplished properly if the correct tip is used. In order to select the right tip, you must know how to identify the size of the tip and determine the range of application suggested by the manufacturer of the tips you use. Proper use and care of the torch tip is important to its useful life.

H. Competency

Select appropriate tip for the job to be performed.

I. Answers to Evaluation

1. c
2. d
3. a
4. c
5. a
6. e
7. d
8. b
9. c
10. a

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ________________

Lesson 3: Proper Tip Selection Date ________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. A tip is identified by the ____________.

   a. Metal to be welded
   b. Cost of the tip
   c. Diameter of the hole in the tip
   d. Diameter of the shank of the welding tip
   e. Type of threads on the tip

2. Which of the following tools is not used to clean a welding tip?

   a. Tip nip
   b. Sandpaper
   c. Tip cleaner
   d. Oily rag
   e. Tip drill

3. Which of the following is a reason to clean the welding tip?

   a. To remove carbon buildup
   b. To make the hole in the tip larger so that thicker metal may be welded with the tip
   c. To reduce the hole in the tip
   d. To make a smooth surface for the slag to stick to
   e. To shorten the life of the tip

4. How can you tell the size of the tip?

   a. By the threads on the shank
   b. Guess
   c. The number stamped on the tip
   d. Calling the manufacturer
   e. Measuring the flame it makes

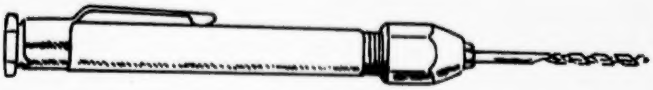
5. Which of the following statements is true for using a welding tip?

   a. Shut off the torch before laying it down.
   b. Dropping the tip on the floor helps to get rid of carbon and slag.
   c. Any size of tip cleaner can be used.
   d. The tip should be tightened with a pair of pliers.
   e. Put a cold tip on a hot torch body.

Match the picture on the right with correct name on the left.

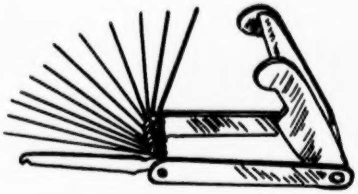
6. _____ Tip nip

a.



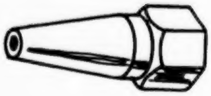
7. _____ Rosebud tip

b.



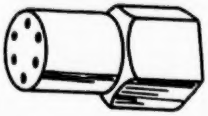
8. _____ Tip cleaner

c.



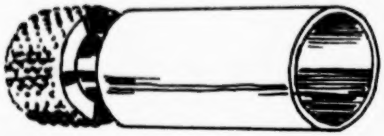
9. _____ Welding tip

d.



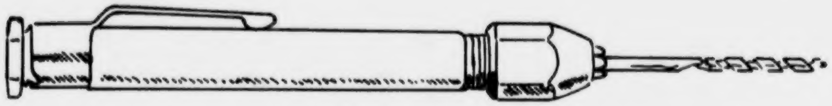
10. _____ Tip drill

e.

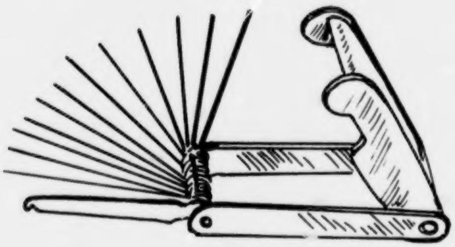


WELDING TIP DATA

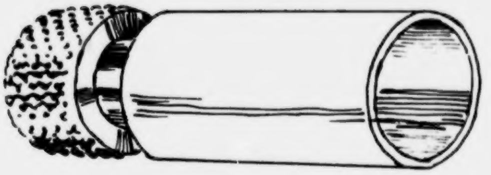
Metal Thickness	Tip Size	Drill Size	Oxygen Pressure P.S.I.G.		Acetylene Pressure P.S.I.G.		Acetylene Consumption SCFH	
			Min.	Max.	Min.	Max.	Min.	Max.
Up to 1/32"	000	75	3	5	3	5	3/4	1 1/2
1/64" - 3/64"	00	70	3	5	3	5	1 1/2	2 1/2
1/32" - 5/64"	0	65	3	5	3	5	2 1/2	4
3/64" - 3/32"	1	60	3	5	3	5	4	6
1/16" - 1/8"	2	56	3	5	3	5	6	10
1/8" - 3/16"	3	53	4	7	3	6	9	18
3/16" - 1/4"	4	49	5	10	4	7	15	28
1/4" - 1/2"	5	43	6	12	5	8	22	40
1/2" - 3/4"	6	36	7	14	6	9	30	52
3/4" - 1 1/4"	7	30	8	16	7	10	38	66
1 1/4" - 2"	8	29	10	19	8	12	48	82
2" - 2 1/2"	9	28	12	22	9	14	58	100
2 1/2" - 3"	10	27	14	24	10	14	70	118
3" - 3 1/2"	11	26	16	26	11	15	84	138
3 1/2" - 4"	12	25	18	28	12	15	100	160



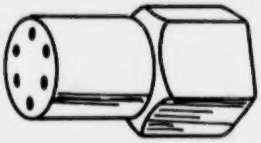
Tip Drill



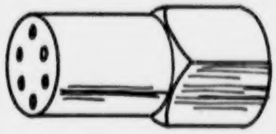
Tip Cleaner



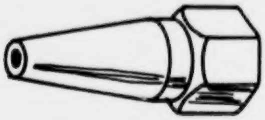
Tip Nip



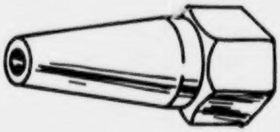
Oxy-Acetylene Heating Tip



Oxygen-Natural Gas or Propane Heating Tip



Oxy-Acetylene Welding Tip



Oxygen-Natural Gas or Propane Heating Tip

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 4: Oxy-Acetylene Welding

Objective: The student will be able to oxy-acetylene weld in the flat, horizontal, vertical, and overhead positions.

References

1. Demonstration Sheets
   - a) DS 4.1: Oxy-Acetylene Welding in the Flat Position
   - b) DS 4.2: Oxy-Acetylene Welding in the Horizontal Position
   - c) DS 4.3: Oxy-Acetylene Welding in the Vertical Position
   - d) DS 4.4: Oxy-Acetylene Welding in the Overhead Position
2. Job Sheets
   - a) JS 4.1: Oxy-Acetylene Welding in the Flat Position
   - b) JS 4.2: Oxy-Acetylene Welding in the Horizontal Position
   - c) JS 4.3: Oxy-Acetylene Welding in the Vertical Position
   - d) JS 4.4: Oxy-Acetylene Welding in the Overhead Position

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 4: **Oxy-Acetylene Welding**

TEACHING PROCEDURES

A. **Review**

Review Lesson 3 on proper welding tip selection.

B. **Motivation**

Using various supply and equipment catalogs, have students look through to see what types of implements and other structures are constructed with oxy-acetylene welding techniques. List these on the board, then ask students to discuss the various types of welds that could have been used on the equipment. Ask the students to devise the best and easiest methods to accomplish the listed welds.

C. **Assignment**

D. **Supervised study**

E. **Discussion**

Discuss skills to be performed on JS 4.1 through JS 4.4. A demonstration sheet is provided for the instructor for each job sheet. No job sheets are included for butt and corner welds in the flat position since they are covered in the Agricultural Science II Core Curriculum. Each job sheet should be graded independently to evaluate the student's competency level for each of the welds.

F. **Other activities**

1. Collect and display outstanding welds and award a "welder of the week" throughout the unit. Use these welds as teaching aids for other students.
2. Have each student make their own welding board. Attach their best weld of each position and joint to an acceptable size board (suggest 24" x 24"-1/4 plywood). Label each weld and display at a science or job fair, or the county fair.

G. **Conclusion**

Being able to master the techniques and skills involved in oxy-acetylene welding takes time, concentration, and practice. Welding is a valuable tool to individuals involved in agribusiness and other sectors of the industry. It can be utilized in numerous ways for numerous reasons. A good welder should have no trouble finding a job.

H. **Competency**

Weld in all positions with oxy-gas welder.
a. Weld in flat position.
b. Weld in horizontal position.
c. Weld in vertical position.
d. Weld in overhead position.

I. Answers to Evaluation

The evaluation for this unit will be the student's performance on the job sheets for welds in each position.

Demonstration Sheet 4.1: Oxy-Acetylene Welds in the Flat Position

Objective: At the completion of this demonstration, the student will be ready to begin Job Sheet 4.1 on oxy-acetylene welding in the flat position.

Tools Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Four pieces of mild steel - size to be determined by the instructor.
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the flat position.

3. Start the weld at the right edge of the metal. A 45-degree work angle and a 15-45 degree travel angle away from the direction of travel should be maintained.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion to move across the joint, holding the tip about 1/8" from the metal.

5. As you move the puddle across the joint, use the filler rod to add metal to the puddle. Hold the filler rod at a 35-40 degree angle. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

6. Move the weld puddle across the joint, maintaining a weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

7. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the flat position.

3. Maintain a 45-degree work angle and a 15-45 degree travel angle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. Holding the tip about 1/8" from the metal.

5. As you move the puddle across the joint, use the filler rod to add metal to the puddle. Hold the filler metal at a 35-40 degree angle. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

6. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

7. Maintain a uniform bead width. Avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Clean and examine the welds for accuracy and appearance.

3. Assign JS 4.1 to be completed by students.

Demonstration Sheet 4.2: Oxy-Acetylene Welding in the Horizontal Position

Objective: At the completion of this demonstration, the student will be ready to begin Job Sheet 4.2 on oxy-acetylene welding in the horizontal position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor.
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

BUTT JOINT

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 5-10 degree work angle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. This motion will create a shelf to control the effects of gravity on the molten puddle.

5. Start the weld at the right of the metal, maintaining a 5-10 degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

6. Concentrate the flame on the lower side of the joint to prevent buildup of the molten metal.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 5-10 degree work angle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. Form a small puddle at the beginning of the weld so that a shelf will be created to help control the weld puddle.

5. Maintain a 5-10 degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

6. If problems are encountered by gravity pulling the weld puddle down, lift the flame away from the weld puddle for a second to allow the puddle to solidify. Move the flame back in to melt the puddle and continue welding.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at the opposite angle of the tip. The

filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then be moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you reach the end of the weld, the travel angle of the tip should be decreased to prevent metal from running off the end of the metal.

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 45-degree work angle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

5. Maintain a 45-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

6. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then be moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration.

9. As you reach the end of the weld, decrease the travel angle of the tip to prevent metal from dripping off the end of the metal.

T-FILLET JOINT

1. Tack weld pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 45-degree work angle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack

weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. This motion will help to build a shelf to control the effects of gravity on the molten puddle.

5. Maintain a 15-40 degree travel angle away from the direction of travel and a 35-40 degree angle for the filler rod.

6. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you reach the end of the weld, the travel angle should be decreased to prevent the puddle from running off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Clean and examine the welds for accuracy and appearance.

3. Assign JS 4.2 to be completed by students.

Demonstration Sheet 4.3: Oxy-Acetylene Welding in the Vertical Position

Objective: At the completion of this demonstration, the student will be ready to begin Job Sheet 4.3 on oxy-acetylene welding in the vertical position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

BUTT JOINT

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the joint, holding the tip at a 90 degree work angle.

4. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. In vertical welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld will sag.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle up the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the metal, holding the tip at a 90 degree work angle.

4. Maintain a 45-degree travel angle away from the direction of travel and 25-30 degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.

6. In vertical welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld will sag. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle up the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the metal, holding the tip at a 45-degree work angle. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.

5. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod.

6. In vertical welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld will sag. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle up the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle up the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the metal, holding the tip at a 45-degree work angle. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal. This motion will help to build a shelf to control the effects of gravity on the molten puddle.

5. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod.

6. In vertical welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld will sag. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle up the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then moved to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle up the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" work distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Clean and examine the weld for accuracy and appearance.

3. Assign JS 4.3 to be completed by students.

Demonstration Sheet 4.4: Oxy-Acetylene Welding in the Overhead Position

Objective: At the completion of this demonstration, the student will be ready to begin Job Sheet 4.4 on oxy-acetylene welding in the overhead position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing**
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

**Protective clothing is very critical in overhead welding. All exposed areas of the body should be covered with protective clothing. A welding cap should be worn to prevent sparks from burning your head. Stand to one side of the weld to prevent sparks and molten metal from dropping on you while welding. Avoid sitting down during overhead welding so that sparks do not land in your lap.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

BUTT JOINT

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the overhead position.

3. Begin the weld at the right edge of the metal, while holding the tip at a 90-degree angle.

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at the opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the overhead position. The metal should be positioned so that it is above your head.

3. Begin the weld at the right edge of the metal, while maintaining a 90-degree work angle.

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the

weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at the opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint. The edges of the metal should have a 1/8" space between them to allow for contraction of the metal.

2. Position the metal so that the joint to be welded is in the overhead position. The metal should be positioned so that it is above your head.

3. Begin the weld at the right edge of the metal, while maintaining a 45-degree work angle.

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the

desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the overhead position. The metal should be positioned so that it is above your head.

3. Begin the weld at the right side of the metal, while holding the tip at a 45-degree work angle.

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at an opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Clean and examine the weld for accuracy and appearance.

3. Assign JS 4.4 to be completed by students.

Job Sheet 4.1: Oxy-Acetylene Welds in the Flat Position

Objective: At the completion of this job sheet, the student will be able to oxy-acetylene weld in the flat position.

Tools Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Four pieces of mild steel - size to be determined by the instructor.
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the flat position.

3. Start the weld at the right edge of the metal, holding the tip at a 45-degree work angle, as illustrated in Figure 4.1.

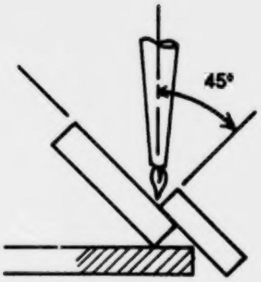


Figure 4.1

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

5. As you move the puddle across the joint, use the filler rod to add metal to the puddle. A 15-45 degree angle away from the direction of travel should be maintained, while holding the filler rod at a 35-40 degree angle, as shown in Figure 4.2.

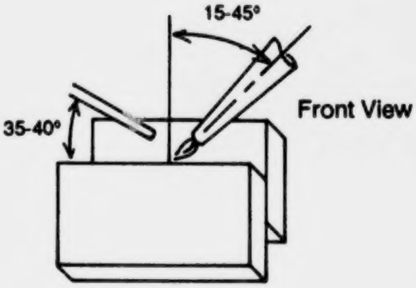


Figure 4.2

6. Use the filler rod to add metal to the puddle as you move across the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the flat position.

3. A 45-degree work angle should be maintained, as illustrated in Figure 4.3.

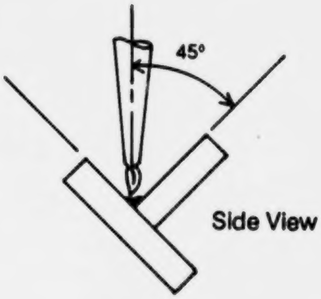


Figure 4.3

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

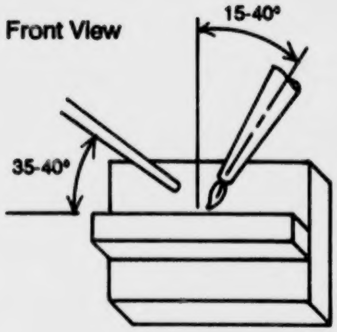


Figure 4.4

5. As you move the puddle across the joint, use the filler rod to add metal to the puddle. A 15-45 degree travel angle away from the direction of travel should be maintained, while holding the filler metal at a 35-40 degree angle, as shown in Figure 4.4.

6. Move the weld puddle across the joint, maintaining the weaving motion with the tip, while moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

7. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)

2. Clean and examine the welds for accuracy and appearance.

3. Turn in the welds to the instructor for grading.

4. Clean the work area.

Job Sheet 4.2: Oxy-Acetylene Welding in the Horizontal Position

Objective: At the completion of this job sheet, the student will be able to oxy-acetylene weld in the horizontal position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor.
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

Welding Procedure:

BUTT JOINT

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

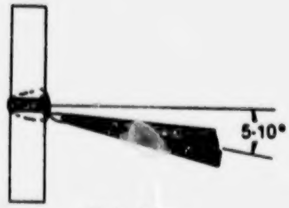
4. Start the weld at the right edge of the metal, holding the tip at a 5-10 degree work angle, as shown in Figure 4.1. Maintain a 5-10 degree travel angle away from the direction of travel and a 45-degree angle for the filler rod, as illustrated in Figure 4.2.

5. Concentrate the flame on the lower side of the joint to prevent buildup of the molten metal.

6. Use the filler rod to add metal to the puddle as you move across the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

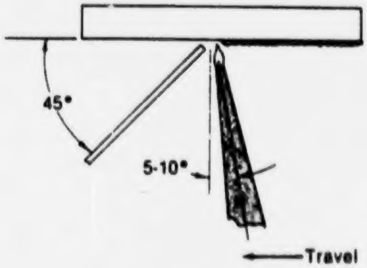
7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.



Side View

Figure 4.1



Top View

Figure 4.2

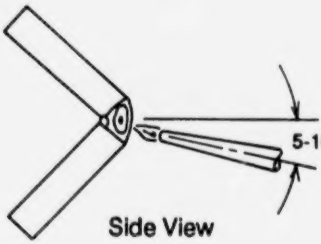
CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 5-10 degree work angle, as shown in Figure 4.3.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.



Side View

Figure 4.3

5. Maintain a 5-10 degree travel angle away from the direction of travel and a 45-degree angle for the filler rod, as shown in Figure 4.4.

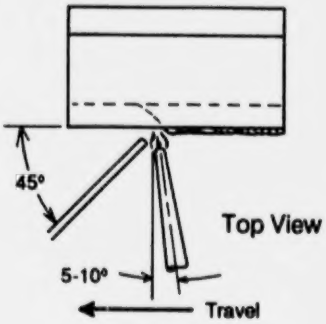


Figure 4.4

6. If problems are encountered by gravity pulling the weld puddle down, lift the flame away from the weld puddle for a second to allow the puddle to solidify. Move the flame back in to melt the puddle and continue welding.

7. Use the filler rod to add metal to the puddle as you move across the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

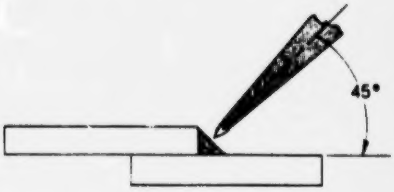
8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you reach the end of the weld, the travel angle of the tip should be decreased to prevent metal from running off the end of the metal.

LAP JOINT

1. Tack weld the two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the horizontal position.



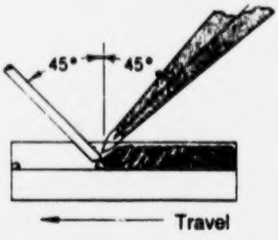
Side View

Figure 4.5

3. Start the weld at the right edge of the metal, holding the tip at a 45-degree work angle, as shown in Figure 4.5.

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

5. Maintain a 45-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod, as shown in Figure 4.6.



Front View

Figure 4.6

6. Use the filler rod to add metal to the puddle as you move across the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move to the outer cone of the flame.

Allow the flame to melt the base metal before moving it back into the inner cone.

7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

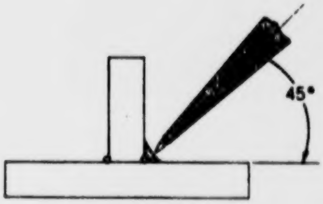
8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you reach the end of the weld, decrease the travel angle of the tip to prevent metal from dripping off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the horizontal position.

3. Start the weld at the right edge of the metal, holding the tip at a 45-degree work angle, as shown in Figure 4.7.

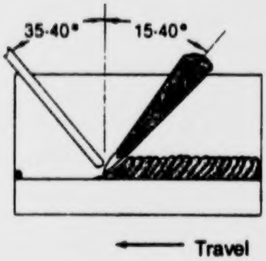


Side View

Figure 4.7

4. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

5. Maintain a 15-40 degree travel angle away from the direction of travel and a 35-40 degree angle for the filler rod, as illustrated in Figure 4.8.



Front View

Figure 4.8

6. Use the filler rod to add metal to the puddle as you move across the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

7. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

8. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you reach the end of the weld, the travel angle should be decreased to prevent the puddle from running off the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)
2. Clean and examine the welds for accuracy and appearance.
3. Turn in the welds to the instructor for grading.
4. Clean the work area.

Job Sheet 4.3: Oxy-Acetylene Welding in the Vertical Position

Objective: At the completion of this job sheet, the student will be able to oxy-acetylene weld in the vertical position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor.
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in your hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

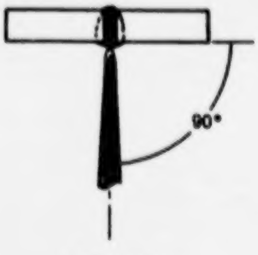
Welding Procedure:

BUTT JOINT

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the joint, holding the tip at a 90-degree work angle, as illustrated in Figure 4.1.



Top View

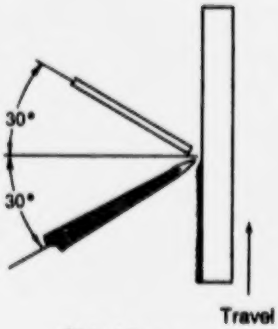
Figure 4.1

4. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod, as shown in Figure 4.2.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.

6. If the weld puddle is too large, the weld will sag. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle up the joint, use the filler rod to add metal to the puddle. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.



Side View

Figure 4.2

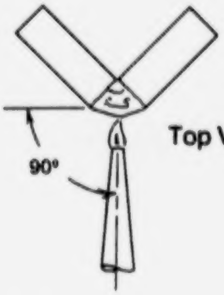
8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the vertical position.



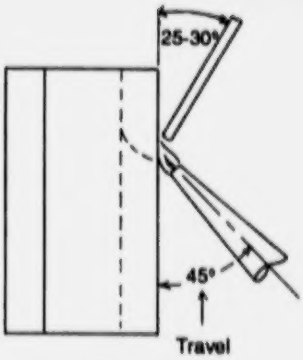
Top View

Figure 4.3

3. Start the weld at the bottom of the metal, holding the tip at a 90-degree work angle, as shown in Figure 4.3.

4. Maintain a 45-degree travel angle away from the direction of travel and a 25-30 degree angle for the filler rod, as illustrated in Figure 4.4.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.



Side View

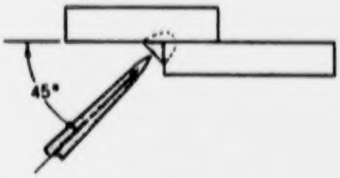
Figure 4.4

6. In vertical welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld will sag. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. Use the filler rod to add metal to the puddle as you move up the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle up the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.



Top View

Figure 4.5

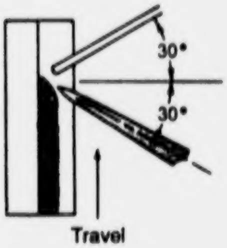
LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the joint, holding the tip at a 45-degree work angle, as shown in Figure 4.5.

4. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod, as illustrated 4.6.



Side View

Figure 4.6

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. Use the filler rod to add metal to the puddle as you move up the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle up the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

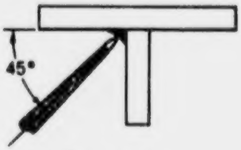
9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the vertical position.

3. Start the weld at the bottom of the metal, holding the tip at a 45-degree work angle, as shown in Figure 4.7.



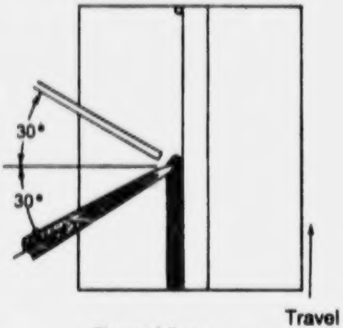
Top View

Figure 4.7

4. Maintain a 30-degree travel angle away from the direction of travel and a 30-degree angle for the filler rod, as shown in Figure 4.8.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move up the joint, holding the tip about 1/8" from the metal.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.



Front View

Figure 4.8

7. Use the filler rod to add metal to the puddle as you move up the joint. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle up the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)

2. Clean and examine the welds for accuracy and appearance.

3. Turn in the welds to the instructor for grading.

4. Clean the work area.

Job Sheet 4.4: Oxy-Acetylene Welding in the Overhead Position

Objective: At the completion of this job sheet, the student will be able to oxy-acetylene weld in the overhead position.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Welding goggles*
3. Safety glasses*
4. Pliers
5. Wire brush
6. Leather gloves
7. Protective clothing**
8. Weld positioner

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

**Protective clothing is very critical in overhead welding. All exposed areas of the body should be covered with protective clothing. A welding cap should be worn to prevent sparks from burning your head. Stand to one side of the weld to prevent sparks and molten metal from dropping on you while welding. Avoid sitting down during overhead welding so that sparks do not land in your lap.

Materials Needed:

1. Eight pieces of mild steel - size to be determined by the instructor
2. Mild steel filler rod - same diameter as the metal

Prewelding Procedure:

1. Remove dirt, grease, and oil from surface of the metal to be welded.

2. Attach a tip appropriate for the metal selected and the torch body used.

3. Set acetylene and oxygen pressure settings appropriate for the tip selected and the torch body used.

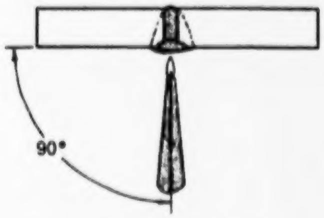
4. Follow the correct procedure to light the torch and adjust to a neutral flame. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Heat an area 8-10 inches from the end of the filler rod and bend a 45-degree angle in the rod where heat was applied. The bend will prevent your hand from being in line with the heat coming from the weld area. The end of the filler rod that will be held in you hand should have a 90-degree bend about 2 inches from the end to prevent you from picking up the hot end of the rod.

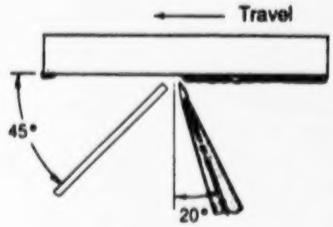
Welding Procedure:

BUTT JOINT



Side View

Figure 4.1



Front View

Figure 4.2

1. Tack weld two pieces of mild steel together to form a butt joint.

2. Position the metal so that the joint to be welded is in the overhead position.

3. Begin the weld at the right edge of the metal, while holding the tip at a 90-degree work angle, as illustrated in Figure 4.1.

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod, as shown in Figure 4.2.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

6. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at the opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

CORNER JOINT

1. Tack weld two pieces of mild steel together to form a corner joint.

2. Position the metal so that the joint to be welded is in the overhead position.

3. Begin the weld at the right edge of the metal, while holding the tip at a 90-degree work angle, as illustrated in Figure 4.3.

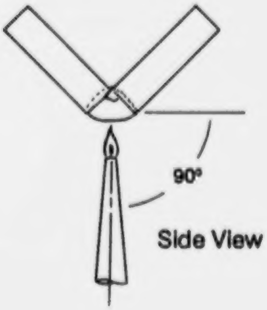


Figure 4.3

4. Maintain a 20-degree travel angle away from the direction of travel and a 45-degree angle for the filler rod, as shown in Figure 4.4.

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

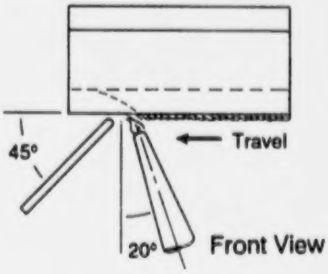


Figure 4.4

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should be held at the top of the joint at the opposite angle of the tip. Dip the filler rod in the puddle as the flame is moved away to prevent the drop from the rod from falling off before it joins the weld puddle. As the flame is returned to the puddle, the filler rod should be removed.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

LAP JOINT

1. Tack weld two pieces of mild steel together to form a lap joint.

2. Position the metal so that the joint to be welded is in the overhead position.

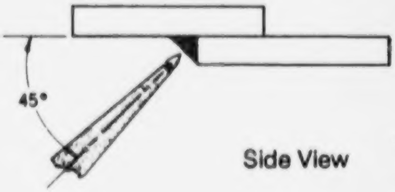


Figure 4.5

3. Begin the weld at the right edge of the metal, while holding the tip at a 45-degree work angle, as illustrated in Figure 4.5.

4. Maintain a 15-45 degree travel angle away from the direction of travel and a 35-40 degree angle for the filler rod, as shown in Figure 4.6.

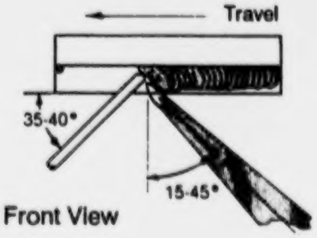


Figure 4.6

5. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

6. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity.

7. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

8. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

9. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

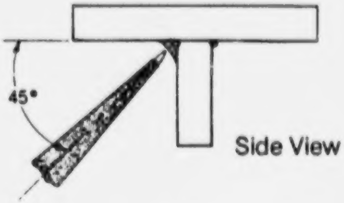


Figure 4.7

T-FILLET JOINT

1. Tack weld two pieces of mild steel together to form a T-fillet joint.

2. Position the metal so that the joint to be welded is in the overhead position.

3. Begin the weld at the right edge of the metal, while holding the tip at a 45-degree work angle, as illustrated in Figure 4.7.

5. Maintain a 15-45 degree travel angle away from the direction of travel and a 35-40 degree angle for the filler rod, as shown in Figure 4.8.

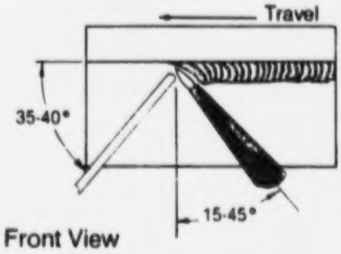


Figure 4.8

6. Move the flame of the torch to the edge of the metal and hold it there until a pool of molten metal is formed. The flame will need to be held for a short time to melt the

tack weld and establish the weld puddle. When the metal begins to melt, use a weaving motion as you move across the joint, holding the tip about 1/8" from the metal.

7. In overhead welding, it is important that the weld puddle be kept small to maintain control. If the weld puddle is too large, the weld metal will drop out of the puddle from the pull of gravity. If the weld puddle becomes too hot, pull the tip away slightly to allow it to cool.

8. As you move the puddle across the joint, use the filler rod to add metal to the puddle. The filler rod should only remain in the inner cone of the flame long enough to add a few drops of metal, then move it to the outer cone of the flame. Allow the flame to melt the base metal before moving it back into the inner cone.

9. Move the weld puddle across the joint, maintaining the weaving motion with the tip and moving the filler rod in and out of the inner cone. Both hands will be in constant motion during the welding process.

10. Maintain a uniform bead width and a 1/8" distance from the tip to the metal to get the desired penetration. As you near the end of the weld joint, avoid adding too much filler metal to the weld puddle or the puddle will drip off the end of the metal.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)

2. Clean and examine the welds for accuracy and appearance.

3. Turn in the welds to the instructor for grading.

4. Clean the work area.

Lesson 5: Hardsurfacing

Objective: The student will be able to perform a hardsurfacing operation with oxy-acetylene.

Study Questions

1. **What is hardsurfacing?**
2. **What kinds of metal may be hardsurfaced?**
3. **How do surfacing procedures and precautions differ for the kinds of metal to be hardsurfaced?**
4. **When should oxy-acetylene be used for hardsurfacing?**
5. **How is hardsurfacing accomplished with oxy-acetylene welding equipment?**
6. **What are the advantages of using oxy-acetylene for hardsurfacing?**
7. **How are hardsurfacing materials used for oxy-acetylene welding classified?**
8. **What is metallizing?**
9. **What equipment is used for metallizing?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. American Technical Publishers: Alsip, NY, 1985.
2. Demonstration Sheet
    a) DS 5.1: Hardsurfacing With Oxy-Acetylene
3. Job Sheet
    a) JS 5.1: Hardsurfacing With Oxy-Acetylene

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 5: Hardsurfacing

TEACHING PROCEDURES

A. Review

Review the previous lessons on oxy-acetylene safety procedures and handling the torch. Emphasize the application of hardsurfacing for agricultural and industrial uses.

B. Motivation

Bring in parts of equipment such as bucket teeth, plowshares, or cultivator sweeps that are in need of hardsurfacing. Ask students the efficiency of the used parts and how they can be altered for longer life.

C. Assignment

D. Supervised study

E. Discussion

1. Hardsurfacing increases the size, hardness, and working life of machine parts and equipment. Discuss the agricultural and industrial uses of hardsurfacing.

   What is hardsurfacing?

   a) Hardsurfacing is a process of applying a hard, wear-resistant alloy which is formulated to resist abrasion, corrosion, high temperature, and impact.
   b) Hardsurfacing is sometimes called hard facing or case hardening.

2. All types of common steel may be hardsurfaced. Steels with lower percentages of carbon are more apt to require hardsurfacing. List common steels on the board and categorize them based on the carbon content.

   What kinds of metals may be hardsurfaced?

   a) Metals with physical properties that are not changed during surfacing
      1) Low-carbon steels - thin sheet metal, mower decks
      2) Medium-carbon steels - car bodies
      3) Low-alloy steels - any structural steel
      4) Stainless steels - kitchen sink, milk tank
   b) Metals with physical properties that change during surfacing, such as undoing heat treatment and producing cracks
      1) High-carbon steels
      2) Cast irons
      3) Other alloy steels

3. Different metals require adjustment in the hardsurfacing procedure. The degree of carbon content is the influencing factor. Discuss how hardsurfacing procedures differ for various steels.

How do surfacing procedures and precautions differ for the kinds of metal to be hardsurfaced?

a) Precautions are not necessary for metals whose physical properties do not change during hardsurfacing since cracking of the metal does not occur.
b) Metals that have physical properties which change need to be preheated and postheated to reduce their hardness and the possibility of harmful cracking.

4. There are times for using oxy-acetylene for hardsurfacing. Discuss the situations when oxy-acetylene should be used for hardsurfacing.

When should oxy-acetylene be used for hardsurfacing?

a) For small parts
b) Where smooth, thin layers are needed
c) When preheating and slow cooling must be controlled
d) When welding unit must be brought to the work; no electricity required

NOTE: The limitation for oxy-acetylene hardsurfacing is the slow deposition rate.

5. An oxy-acetylene torch is common to nearly all farm shops and equipment repair shops. Discuss how hardsurfacing is accomplished with oxy-acetylene welding equipment.

How is hardsurfacing accomplished with oxy-acetylene welding equipment?

a) A slightly carburizing flame is recommended.
b) Preheat the surface to produce a "sweating" condition.
c) The tip of the rod is held on the fringe of the flame during preheating.
d) Move rod to center of flame to be melted.
e) Deposit filler rod with regular welding techniques, using the slight weaving motion.

6. Discuss the advantages of hardsurfacing with oxy-acetylene.

What are the advantages of using oxy-acetylene for hardsurfacing?

a) Dilution of hardsurfacing alloy can be held to a minimum.
b) Thickness of deposit can be minimized.
c) Oxy-acetylene flame can be used with all hardsurfacing alloys.
d) Equipment can be taken to the work.

7. There are four general categories of hardsurfacing alloys available. Discuss the categories with students and identify how the alloys are classified.

How are hardsurfacing materials used for oxy-acetylene welding classified?

a) Low-alloy iron-base (e.g., nucore steel, chapparel steel)
b) High-alloy iron-base (e.g., wearalloa)
c) Cobalt-base and nickel-base (e.g., all cast irons)
d) Tungsten-carbide (e.g., wearalloa)

NOTE: The instructor should use DS 5.1 to demonstrate hardsurfacing. Assign JS 5.1 for students to complete.

8. **Metallizing is different from hardsurfacing in that special equipment is required. Introduce the students to the technique of metallizing.**

   What is metallizing?

   Metallizing is a spray coating process in which fine semi-molten metal particles or metal powder is deposited on surfaces where metal has worn away.

9. **There are different methods of metallizing, each used for various reasons. Discuss the various methods of metallizing with the class.**

   What equipment is used for metallizing?

   a) Wire spray guns
   b) Electric-arc metallizing
   c) Oxy-acetylene metal-spray torch

F. Other activities

1. Have students bring in parts which need to be hardsurfaced and compare them with parts which have already been hardsurfaced.

2. Have a welding company representative or salesperson bring in various equipment parts that require hardsurfacing. Have the representative give a demonstration on hardsurfacing.

G. Conclusion

Hardsurfacing saves money, time, fuel, and energy when used on agricultural and industrial equipment parts. Oxy-acetylene is often used for hardsurfacing because it can easily be used in the field as well as the shop. Preheating and postheating can be controlled using oxy-acetylene. Metallizing, a process similar to hardsurfacing, is also used in many agricultural situations. The equipment used for metallizing may require electricity, thus eliminating the mobility of the process.

H. Competency

Perform a hardsurfacing operation.

I. Answers to Evaluation

1. c
2. a
3. d
4. d
5. d
6. b
7. e
8. a
9. c
10. b

Name ____________________

Lesson 5: Hardsurfacing

Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Hardsurfacing affects the physical properties of which of the following metals?

   a. Low-carbon steels
   b. Medium-carbon steels
   c. High-carbon steels
   d. Low-alloy steels
   e. Stainless steels

2. Which of the following metals is most likely to crack when being hardsurfaced without preheating and postheating?

   a. Cast iron
   b. Stainless steel
   c. Low-alloy steel
   d. Medium-carbon steel
   e. Low-carbon steel

3. Which of the following flames is used for melting the filler rod when hardsurfacing?

   a. Neutral
   b. Oxidizing
   c. Metallizing
   d. Carburizing
   e. Fillerizing

4. Which of the following is an advantage for using oxy-acetylene in hardsurfacing?

   a. Either AC or DC can be used.
   b. Fast deposit rates are achieved.
   c. It can be used for large areas.
   d. Smooth thin layers result.
   e. Dilution of alloy is not affected.

5. For best results when hardsurfacing, the work should be placed in the __________.

   a. Overhead position
   b. Vertical position
   c. Horizontal position
   d. Flat position
   e. Inclined position

6. Which of the following equipment parts would not be hardsurfaced?

   a. Plowshares
   b. Chainsaw teeth
   c. Cultivator sweeps
   d. Auger teeth
   e. Bucket teeth

7. Which of the following is not a classification of hardsurfacing materials used for oxyacetylene?

   a. Low-alloy iron base
   b. Tungsten-carbide
   c. High-alloy iron base
   d. Cobalt base and nickel base
   e. Hard base

Match the phrase on the right side with the appropriate one on the left.

8. _____ Type of metal in which a change of properties occurs when heated

9. _____ Type of flame used

10. _____ Type of metal in which no change of properties occurs when heated

a. Cast iron

b. Low-carbon steel

c. Slightly carburizing

Demonstration Sheet 5.1: Hardsurfacing with Oxy-Acetylene

Objective: At the completion of this demonstration, the student will be ready to begin JS 5.1 on oxy-acetylene hardsurfacing.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Brazing tip
3. Welding goggles*
4. Safety glasses*
5. Face shield
6. Welding gloves
7. Portable grinder
8. Vise
9. Pliers
10. Wire brush
11. Firebrick table

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of steel to be hardsurfaced - size to the determined by the instructor
2. Hardsurfacing rod - size determined by instructor
3. Flux

Presurfacing Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Place the steel to be hardsurfaced in a vise and grind it approximately 1" along the edge until the metal is bright.

   CAUTION: Always wear safety glasses and a face shield when grinding.

4. Place the metal on the table at a 25-degree angle.

5. Connect the hardsurfacing tip to the torch body.

6. Correctly light the torch and adjust to a neutral flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

7. Preheat the steel to be hardsurfaced.

Surfacing Procedure:

1. Adjust to a carburizing flame. Move flame down until it is about 1/8" above the surface of the work piece. Hold the flame still until the edge surface of the tool begins to sweat and looks glazed.

2. The rod should be brought between the inner cone and the base metal, almost touching the metal.

3. A slight weave of the torch is used to deposit one or two drops of molten alloy to the metal surface.

   NOTE: If the molten alloy does not flow easily and spread uniformly, it usually indicates the base metal needs more preheating.

4. The rod should be withdrawn and used to spread the alloy metal around the surface of the base metal.

5. Continue moving the rod in and out of the flame and spreading the alloy metal around until the entire area to be hardsurfaced is covered.

Postsurfacing Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Inspect the surface of the metal for quality and appearance.

3. Assign JS 5.1 to be completed by students.

Job Sheet 5.1: Hardsurfacing With Oxy-Acetylene

Objective: At the completion of this job sheet, the student will be able to hardsurface with oxy-acetylene.

Tools and Equipment Needed:

1. Oxy-acetylene unit
2. Brazing tip
3. Welding goggles*
4. Safety glasses*
5. Face shield
6. Welding gloves
7. Portable grinder
8. Vise
9. Pliers
10. Wire brush
11. Firebrick table

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of steel to be hardsurfaced- size to be determined by the instructor
2. Hardsurfacing rod - size determined by instructor
3. Flux

Presurfacing Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Place the steel to be hardsurfaced in a vise and grind it approximately 1" along the edge until the metal is bright.

   CAUTION: Always wear safety glasses and a face shield when grinding.

4. Place the metal on the table at a 25-degree angle.

5. Connect the hardsurfacing tip to the torch body.

   CAUTION: Welding goggles must be worn from the time that the torch is lit until it is shut down. Safety glasses must be worn at all other times.

6. Correctly light the torch and adjust to a neutral flame. (Refer to JS 2.1.)

7. Preheat the steel to be hardsurfaced.

Surfacing Procedure:

1. Adjust to a carburizing flame.
2. Move flame down until it is about 1/8" above the surface of the work piece. Hold the flame still until the edge surface of the tool begins to sweat and looks glazed.
2. The rod should be brought between the inner cone and the base metal, almost touching the metal, as illustrated in Figure 5.1.
3. A slight weave of the torch is used to deposit one or two drops of molten alloy to the metal surface.
4. If the molten alloy does not flow easily and spread uniformly, it usually indicates the base metal needs more preheating.
5. The rod should be withdrawn and used to spread the alloy metal around the surface of the base metal.
6. Continue moving the rod in and out of the flame and spreading the alloy metal around until the entire area to be hardsurfaced is covered.

Postsurfacing Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)
2. Inspect the surface of the metal for quality and appearance.
3. Turn in the metal to the instructor for grading.
4. Clean the work area.

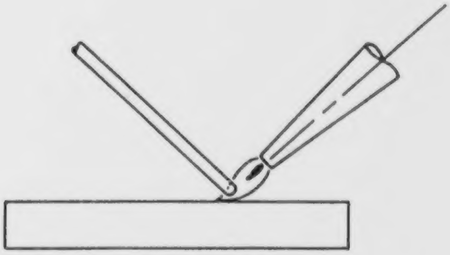


Figure 5.1

Lesson 6: Welding Cast Iron

Objective: The student will be able to weld cast iron.

Study Questions

1. **What is cast iron?**
2. **How are the five principal types of cast iron used?**
3. **How is cast iron prepared for welding with oxy-acetylene?**
4. **What rods and fluxes are used for welding/brazing cast iron with oxy-acetylene?**
5. **Why is heat treatment necessary when welding cast iron?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. American Technical Publishers: Alsip, NY, 1985.
2. Demonstration Sheet
   a) DS 6.1: Welding Cast Iron
3. Job Sheet
   a) JS 6.1: Welding Cast Iron

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 6: Welding Cast Iron

TEACHING PROCEDURES

A. Review

Review the previous lesson on hardsurfacing. Stress the importance of following safety precautions when welding with oxy-acetylene.

B. Motivation

Bring various parts made of cast iron into the laboratory. Have students identify where the machine parts might have come from. Ask the students to bring in a piece of cast iron from some source. Each student should list the advantages and limitations of cast iron.

C. Assignment

D. Supervised study

E. Discussion

1. Compare the costs of properly repairing a cast iron machine part versus purchasing a new part. Ask students to determine considerations in repairing a part made of cast iron.

   What is cast iron?

   a) Cast iron is an alloy of iron, carbon, and silicon.
   b) Carbon content ranges from 1.7 to 4 percent.
   c) Cast iron varies in its uses, based on the physical and mechanical properties of the metal.

2. Cast iron is classified into five principle types. Using samples of the types ask students to compare and determine uses for each type of cast iron.

   How are the five principal types of cast iron used?

   a) White cast iron - forged cast iron parts
   b) Gray cast iron - old cast iron pipe (not used much today)
   c) Malleable cast iron - motor block on head, fittings
   d) Alloy cast iron - any machinable cast, cast steel parts
   e) Nodular or ductile cast iron - cast iron pipe

3. Cast iron requires some preparation and precautions prior to welding. Display cast iron parts that were unsuccessfully repaired because of poor preparation.

   How is cast iron prepared for welding with oxy-acetylene?

   a) Remove impurities by grinding off the surface layer of the metal known as the casting skin. The weld area should be cleaned at least one inch on both sides of the V to be welded.

b) Clean the surface of the metal to remove rust, scale, dirt, and oil.
c) Thin pieces should be cleaned by grinding.
d) Thick pieces 1/4 inch or more should be beveled at a 60-degree angle, leaving a 1/16 inch root face.
e) Grinding residues should be brushed off with a wire brush or by filing.
f) When welding to repair cracks, small holes should be drilled beyond the ends of the crack to prevent them from enlarging.

4. A special rod and flux must be used to properly assure soft, machinable weld deposits when used with correct heat treatment. Pass out several types of rods and let the students inspect them. Write the rod names on the board, and have students select which ones should be used on cast.

What rods and fluxes are used for welding/brazing cast iron with oxy-acetylene?

a) A special cast iron filler rod having the same composition as the base metal is required.
b) A flux is needed to keep the molten puddle fluid.
c) The flux must be specially designed for fusion welding of cast iron.
d) A special brazing flux is used for brazing cast iron.

5. Slow cooling of metal is essential for proper strength. Ask students why this cooling is important. Discuss cooling methods and select a method of cooling best for the available facilities.

Why is heat treatment necessary when welding cast iron?

a) Since cast iron is so brittle, preheating is needed to control expansion and contraction of the metal.
b) Post heating the metal after welding is necessary to relieve stress resulting from the welding procedure.
c) Heat treating prevents brittle white cast iron from forming
d) After completing the post heating, the cast iron should be allowed to cool in sand or lime.

F. Other activities

1. Collect samples of different types of cast iron and exhibit them as a teaching aide.

2. Make a list of uses of cast iron items in agricultural and industrial shops as well as on the farm.

3. Visit a foundry or manufacturing plant to view how metals are manufactured (e.g., tractor factory, automobile factory).

G. Conclusion

Cast iron is important to modern technology. Its strength and endurance are needed for both construction and repair of structures, equipment and parts. Unlike mild steel, cast iron requires several treatments before, during, and after welding to achieve a strong, durable weld.

H. Competency

Weld cast iron using rod and flux.

I. Answers to Evaluation

1. a
2. c
3. b
4. e
5. a
6. b
7. c
8. b
9. c
10. b

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ____________________

Lesson 6: Welding Cast Iron Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer listed.

1. The main components of cast iron are __________.

   a. Iron, carbon, and silicon
   b. Iron, steel, and magnesium
   c. Aluminum and tin
   d. Carbon, boron, and tungsten
   e. Iron, carbon, and molybdenum

2. The carbon content of cast iron ranges from __________.

   a. 1.2 to 2.2 percent
   b. 1.4 to 3.4 percent
   c. 1.7 to 4.0 percent
   d. 2.0 to 5.0 percent
   e. 1.2 to 8.4 percent

3. Which of the following is not a type of cast iron?

   a. White cast iron
   b. Black cast iron
   c. Gray cast iron
   d. Alloy cast iron
   e. Ductile cast iron

4. To prevent cracks from enlarging when welding cast iron, you should __________.

   a. Grind the area
   b. Clamp the work piece
   c. Coat area with dye
   d. Preheat the work piece
   e. Drill small holes

5. The surface layer of cast iron is known as the __________.

   a. Casting skin
   b. Outer casting
   c. Pig skin
   d. Sand liner
   e. Pickle liner

6. To keep the weld puddle liquid, you should use a _________.

   a. Copper rod
   b. Flux
   c. Grinder
   d. Stainless steel rod
   e. Beveled edge

7. To control expansion and contraction forces of cast iron, you should _________.

   a. Grind the edge of the metal
   b. Remove the casting skin
   c. Preheat and postheat
   d. Weld quickly
   e. Dip the metal in cold water after welding

8. Thick pieces of cast iron should be prepared and beveled at what angle before welding?

   a. 40° angle
   b. 60° angle
   c. 50° angle
   d. 20° angle
   e. 70° angle

9. What type of rod should be used when welding cast iron?

   a. Cast iron rod
   b. White rod
   c. Rod having the same composition as the base metal
   d. Rod with a red dot on the end
   e. Any type of rod is suitable

10. Postheat treatment is accomplished by _________.

   a. Quenching the metal in cold water
   b. Allowing the metal to cool in sand or lime
   c. Cooling the metal at room temperature
   d. Dipping the metal in oil
   e. Dipping the metal in boiling water

Demonstration Sheet 6.1: Welding Cast Iron

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on welding cast iron with oxy-acetylene.

Tools and Equipment Needed:

1. Oxy-acetylene welding unit
2. Welding goggles*
3. Safety glasses*
4. Face shield
5. Welding gloves
6. Portable grinder
7. Vise
8. Pliers
9. Chipping hammer
10. Wire brush

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Cast iron - size to be determined by instructor
2. Filler rod - to be selected by instructor
3. Flux - (Flux should not be added if a flux-coated rod is used.)

Prewelding Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Place the cast iron to be welded in a vise and grind it approximately 1" along the edge to remove the casting skin.

   CAUTION: Always wear safety glasses and a face shield when grinding.

4. Make a 60-degree bevel on the edges of the joint if the cast iron exceeds 1/8" in thickness.

5. Light the oxy-acetylene torch and heat both edges to be welded to a dull red. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

Welding Procedure:

1. Adjust the torch to a neutral flame.

2. Tack weld both ends of the metal to control distortion during welding.

3. Position the metal to be welded in the flat position.

4. Hold the torch 1/8" away from the surface of the cast iron. A 90-degree work angle and a 45-degree travel angle should be maintained.

5. Use a circular motion to heat the bottom of the joint until a molten puddle is formed.

6. While melting the bottom of the joint to form the weld puddle, the filler rod should be moved into the outer envelop of the flame to preheat it. When the rod is hot, dip it in the flux.

7. Move the rod into the inner cone and add filler metal to the weld puddle. Continue using a circular motion to melt both sides of the joint into the weld puddle.

8. When the flux is gone from the filler rod, the hot end should be dipped into the flux again. The flame should moved slightly away from the center of the joint while you are dipping the rod in the flux.

9. Once the flux has been added to the filler rod, move the flame back into the joint and continue the procedure until the entire joint has been welded.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Check the weld for accuracy and appearance.

3. Provide the proper postheat treatment of the cast iron by burying the cast iron in sand or lime.

4. Assign JS 6.1 to be completed by students.

Job Sheet 6.1: Welding Cast Iron

Objective: At the end of this job sheet, the student will be able to weld cast iron with oxy-acetylene.

Tools and Equipment Needed:

1. Oxy-acetylene welding unit
2. Welding goggles*
3. Safety glasses*
4. Face shield
5. Welding gloves
6. Portable grinder
7. Vise
8. Pliers
9. Chipping hammer
10. Wire brush

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Cast iron - size to be determined by instructor
2. Filler rod - to be selected by instructor
3. Flux - (Flux should not be added if a flux-coated rod is used.)

Prewelding Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Place the cast iron to be welded in a vise and grind it approximately 1" along the edge to remove the casting skin.

   CAUTION: Always wear safety glasses and a face shield when grinding.

4. Make a 60-degree bevel on the edges of the joint if the cast iron exceeds 1/8" in thickness.

5. Light the oxy-acetylene torch and heat both edges to be welded to a dull red. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

Welding Procedure:

1. Adjust the torch to a neutral flame.

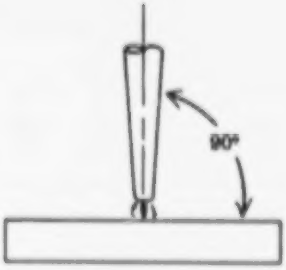


Figure 6.1

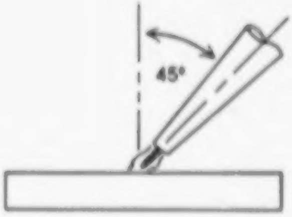


Figure 6.2

2. Tack weld both ends of the metal.
3. Position the metal to be welded in the flat position.
4. Hold the torch 1/8" away from the surface of the cast iron. A 90-degree work angle (Figure 6.1) and a 45-degree travel angle (Figure 6.2) should be maintained.
5. Use a circular motion to heat the bottom of the joint until a molten puddle is formed.
6. Move the filler rod into the outer envelop of the flame until it is heated. Dip the rod in the flux.
7. Move the rod into the inner cone and add filler metal to the weld puddle. Continue using a circular motion to melt both sides of the joint into the weld puddle.
8. Add more flux to the rod when needed to complete the weld. Move the flame away from the center while you are dipping into the flux.
9. Once the flux has been added to the filler rod, move the flame back into the joint and continue the procedure until the entire joint has been welded.

Postwelding Procedure:

1. Follow correct procedure for shutting down the torch. (Refer to JS 2.1.)
2. Check the weld for accuracy and appearance.
3. Properly cool the weld in sand or lime.
4. Turn in the weld to the instructor for grading.
5. Clean the work area.

Lesson 7: Braze Welding

Objective: The student will be able to perform a braze welding operation.

Study Questions

1. **What is braze welding?**
2. **What is the difference between braze welding and brazing?**
3. **What are the advantages and disadvantages of braze welding?**
4. **What type of rod and flux must be used?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. American Technical Publishers: Alsip, NY, 1985.
2. Demonstration Sheet
    - a) DS 7.1: Braze Welding
3. Job Sheet
    - a) JS 7.1: Braze Welding

Lesson 7: Braze Welding

TEACHING PROCEDURES

A. Review

Review the previous lessons on oxy-acetylene safety procedures and handling the torch. Emphasize the differences between braze welding and other welding processes.

B. Motivation

Bring in a piece or a part that has been braze welded along with the rod and flux used. Compare this good weld with one done poorly. Ask students to discuss the differences and why is it easy to have a poor weld.

C. Assignment

D. Supervised study

E. Discussion

1. Braze welding is often referred to as "bronze welding." Discuss the benefits of braze welding and where it can be applied.

   What is braze welding?

   a) Braze welding is a process closely resembling fusion welding.
   b) It is used to join steel, cast iron, copper, and some copper alloys.
   c) In braze welding, the filler metal always has a melting point well below the melting point of the base metal.
   d) The base metal is never melted.

2. Since the process was renamed "braze welding" there has been confusion between the terms "brazing" and "braze welding." Discuss the difference between brazing and braze welding.

   What is the difference between braze welding and brazing?

   a) In braze welding, the filler metal must have a melting point above 800°F but lower than the base metal's melting point. Filler metal flows into the joint by gravity, not by capillary attraction (suction).
   b) In brazing, the filler metal must have a melting point above 800°F but lower than the base metal's melting point. Filler metal is drawn into a tightly fitting joint by capillary attraction.

3. There are a number of advantages and disadvantages of braze welding. List the advantages and disadvantages of braze welding on the board.

   What are the advantages and disadvantages of braze welding?

   a) Advantages

        1) It welds more rapidly because less heat is required.
        2) Less stress is present in the weld.
        3) Dissimilar metals can be joined.
        4) Thin materials have less distortion.
        5) Braze filler has high corrosion resistance.
        6) Metals may be separated at a later time by reheating.
    b) Disadvantages
        1) It cannot be used above melting point temperatures.
        2) It should not be used when the temperature of the reaches above 500°F.
        3) Filler may not be as corrosive resistant as metals being joined.
        4) Color may not match the base materials.

4. The rod used in braze welding produces high tensile strength and ductility. It also helps to deoxidize the weld, reduce fumes, and increase the molten flow. The flux is also important in assuring a clean weld. Ask the students to list major elements in the braze welding rod.

   What type of rod and flux must be used?

   a) The elements of a brazing filler rod are copper and zinc
   b) The rod also contains small amounts of other alloy metals.
   c) There are brazing rods available which already have a flux coating on them.
   d) Flux may be applied to the rod by:
       1) Dipping the heated rod in the flux
       2) Brushing on liquid flux

F. Other activities

1. Have students bring in equipment parts which they think can be repaired by braze welding.

2. Use students' welds as a motivation and learning tool for others to improve their techniques.

G. Conclusion

Braze welding is a very intricate, delicate welding process. When done properly, it has high tensile strength and ductility. Braze welding is a process that can be economically feasible in most any operation.

H. Competency

Perform a braze weld operation.

I. Answers to Evaluation

1. b
2. e
3. b
4. c
5. Brazing - a thin layer of brazing material is used to join metals where the filler material is distributed by capillary action.
   Braze welding - much like fusion welding, filler metal is deposited by gravity

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ____________________

Lesson 7: Braze Welding Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not true about braze welding?

   a. It closely resembles fusion welding.
   b. The base metal is always melted.
   c. Filler metal has melting point below base metal.
   d. It is used to join steel.
   e. It is used to join copper and some copper alloys.

2. Which of the following is an advantage of braze welding?

   a. Welds are completed quickly because more heat is required.
   b. Provides more stress in the weld.
   c. Thick materials have less distortion.
   d. Filler rods are not required.
   e. Dissimilar metals can be joined.

3. Which of the following is a disadvantage of braze welding?

   a. Dissimilar metals can be joined.
   b. Color may not match the base materials.
   c. Thin metals have less distortion.
   d. Less stress results in the weld.
   e. Braze welding filler has high corrosion resistance.

4. The main elements in a braze welding rod are __________.

   a. Copper and iron
   b. Lead and nickel
   c. Copper and zinc
   d. Aluminum and nickel
   e. Chromium and silicon

Complete the following short answer question.

5. Describe how braze welding differs from brazing.

Demonstration Sheet 7.1: Braze Welding

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on braze welding.

Tools and Equipment Needed:

1. Oxy-acetylene welding unit with brazing tip
2. Welding goggles*
3. Safety glasses*
4. Face shield
5. Welding gloves
6. Pliers
7. Chipping hammer
8. Wire brush

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Steel plate - size to be determined by instructor
2. Bronze filler rod - to be selected by instructor
3. Flux (Flux does not need to be added if flux-coated rods are used.)

Prewelding Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Use a grinder to bevel the edges of the metal if it exceeds 1/8" in thickness.

   CAUTION: A face shield should be worn when using a grinder.

4. Add a brazing tip to the torch. Light and adjust the torch to a slightly oxidizing flame. (Refer to DS 2.1.)

   CAUTION: Welding goggles should be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Make a 45-degree angle bend in the rod about halfway up the length to make it easier to handle.

Welding Procedure:

1. Hold the tip of the torch 1/8" from the surface of the metal, while holding it at a 90-degree work angle and a 45-degree travel angle. The filler rod should be held at a 45-degree angle.

2. Use a circular motion to heat a 1/2" area of the metal to a dull red color. Do not melt the base metal.

3. Heat the end of the rod slightly and dip it in the flux.

4. Move the rod into the inner cone of the flame and deposit a drop of bronze into the joint.

5. After the drop of bronze has been added to the weld, move the rod to the outer cone of the flame and use a circular motion of the flame to move the bronze into the joint.

6. Check the rod frequently to make sure it has flux on it. While you are adding flux to the rod, the flame should be withdrawn slightly from the joint to prevent overheating of the base metal.

7. Once the flux has been added to the filler rod, move the flame back into the joint and continue the procedure until the weld is complete.

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to DS 2.1.)

2. Clean the weld and examine it for accuracy and appearance.

3. Assign JS 7.1 to be completed by students.

Job Sheet 7.1: Braze Welding

Objective: At the completion of this job sheet, the student will be able to perform a braze weld.

Tools and Equipment Needed:

1. Oxy-acetylene welding unit with brazing tip
2. Welding goggles*
3. Safety glasses*
4. Face shield
5. Welding gloves
6. Pliers
7. Chipping hammer
8. Wire brush

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Steel plate - size to be determined by instructor
2. Bronze filler rod - to be selected by instructor
3. Flux (Flux is not needed if flux-coated rods are used.)

Prewelding Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Use a grinder to bevel the edges if the metal to be welded exceeds 1/8" in thickness.

   CAUTION: A face shield must be worn when using the grinder.

4. Add a brazing tip to the torch and light. Adjust to slightly oxidizing flame. (Refer to JS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

5. Make a 45-degree angle bend in the rod about halfway up the length to make it easier to handle.

Welding Procedure:

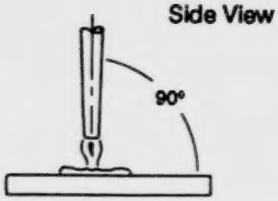


Figure 7.1

1. Hold the tip of the torch 1/8" from the surface of the metal, while holding it at a 90-degree work angle (Figure 7.1) and a 45-degree travel angle (Figure 7.2). The filler rod should be held at a 45-degree angle (Figure 7.2).

2. Use a circular motion to heat a 1/2" area of the metal to a dull red color. Do not melt the base metal.

3. Heat the end of the rod slightly and dip it in the flux.

4. Move the rod into the inner cone of the flame and deposit a drop of bronze into the joint.

5. After the drop of bronze has been added to the weld, move the rod to the outer cone of the flame and use a circular motion of the flame to move the bronze into the joint.

6. Add more flux to the rod when necessary, without overheating the base metal.

7. Once the flux has been added to the filler rod, move the flame back into the joint and continue the procedure until the weld is complete.

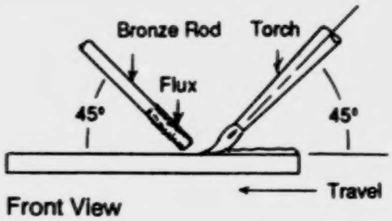


Figure 7.2

Postwelding Procedure:

1. Follow the correct procedure for shutting down the torch. (Refer to JS 2.1.)

2. Clean and examine the weld for accuracy and appearance.

3. Turn in the weld to the instructor for grading.

4. Clean the work area.

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 8: Oxy-Gas Cutting

Objective: The student will be able to properly cut metal with the oxy-gas cutting unit.

Study Questions

1. **What types of cutting can be accomplished with oxy-gas?**
2. **What gases can be used in oxy-gas cutting?**
3. **What are the different types of cutting tips and orifices?**
4. **How do you determine the correct pressures to be used in cutting?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handouts
   a) HO 8.1: Typical Cutting Tips and Orifices
   b) HO 8.2: Cutting Tip Chart
3. Demonstration Sheets
   a) DS 8.1: Making Beveled Cuts
   b) DS 8.2: Cutting Holes With Oxy-Gas
4. Job Sheets
   a) JS 8.1: Making Beveled Cuts
   b) JS 8.2: Cutting Holes With Oxy-Gas

Lesson 8: Oxy-Gas Cutting

TEACHING PROCEDURES

A. Review

Review the previous lessons on oxy-acetylene safety procedures and handling the torch, as well as Lesson 1 of the Oxy-Acetylene unit of the Ag Science I curriculum. Emphasize the versatility of the cutting process and how helpful it becomes in agricultural/industrial businesses. Review the steps for lighting, adjusting, and shutting down the torch. Also, review the procedures for cutting flat metal.

B. Motivation

Bring in various pieces of metal and cutting tips and ask the students to match which piece of metal could be cut using which cutting tip. Ask the students to make a list of the advantages of oxy-gas cutting.

C. Assignment

D. Supervised study

E. Discussion

1. Different, types of cutting can be accomplished by a good welder. Discuss the different types of cutting that can be done.

   What types of cutting can be accomplished with oxy-gas?

   a) Normal cutting of flat steel
   b) Cutting round-bar steel
   c) Beveling
   d) Piercing holes
   e) Cutting cast iron

2. Although acetylene is the main gas used for cutting purposes, there are other acceptable gases that can be used in certain conditions. Discuss the gases that are used in oxy-gas cutting.

   What gases can be used in oxy-gas cutting?

   a) Acetylene - most commonly used, unstable in its natural state
   b) Propane - low heat flame, burns an excess amount of oxygen
   c) MAPP - high temperature flame in outer cone
   d) Hydrogen - colorless flame, expensive
   e) Oxygen - highly flammable, increases the oxidation of metal
   f) Methane - low temperature, low heat flame

3. Selecting and using the correct cutting tip is crucial to obtaining a good cut. Lay the different cutting tips in front of the students and have them discuss the differences. Point out the different sizes and numbers of orifices. Distribute HO 8.1.

   What are the different types of cutting tips and orifices?

   a) Light preheat, light cutting (acetylene)
   b) Medium preheat, light cutting (acetylene)
   c) Heavy preheat, heavy cutting (acetylene)
   d) Medium preheat, gouging (acetylene)
   e) General purpose (propane)
   f) General purpose (methane)

4. The pressure settings for oxygen and gas are just as important as the correct tip selection. Discuss the criteria for determining the correct pressure to use for each. Distribute HO 8.2.

   How do you determine the correct pressures to be used in cutting?

   a) Pressures settings for oxygen and gas depend upon the size of tip used.
   b) Always consult the manufacturer's recommendations for your particular torch.
   c) Rusty or scaly steel might require a greater oxygen pressure.

F. Other activities

1. Visit a nearby welding shop or metal fabrication shop to see the various types of cutting processes in action.

2. Have the students give reports on when each type of cutting should be used.

G. Conclusion

Cutting is used every day in agricultural and industrial businesses. A properly cut piece of metal can be used to the most advantage and results in less waste; therefore, it is more economical to the manufacturer.

H. Competency

Perform cutting with oxy-gas.

I. Answers to Evaluation

1. c
2. b
3. c
4. size of tip, condition of metal
5. b
6. e
7. b
8. a
9. c
10. d

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Name ____________________

Lesson 8: Oxy-Gas Cutting

Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the gases listed can not be used for cutting purposes?

   a) Acetylene
   b) Propane
   c) Helium
   d) MAPP
   e) Argon

2. Which of the following combinations is not recommended for oxy-gas cutting?

   a) Light preheat, light cutting
   b) Light preheat, heavy cutting
   c) Medium preheat, light cutting
   d) Heavy preheat, heavy cutting
   e) Medium preheat, gouging

3. Which of the following can be accomplished with oxy-gas cutting?

   a) Double V cutting
   b) T cutting
   c) Beveling
   d) Lap cutting
   e) Butt cutting

Complete the following short answer question.

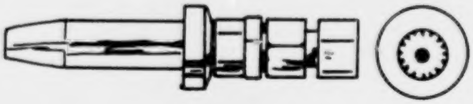
4. What are two factors that determine the amount of oxygen pressure needed for oxy-gas cutting?

   a)

   b)

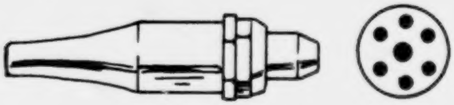
Match the following tips with the correct use. The answers may be used more than once.

____ 5.



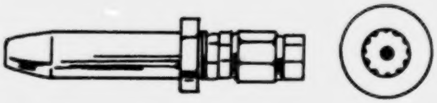
Propane

____ 6.



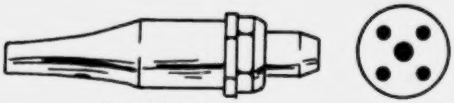
Acetylene

____ 7.



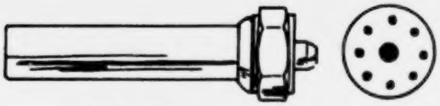
Natural Gas (Methane)

____ 8.



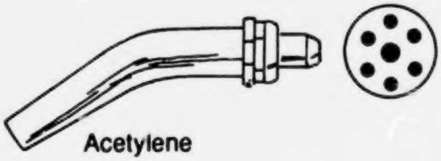
Acetylene

____ 9.



Acetylene

____ 10.



Acetylene

a. Light preheat, light cutting

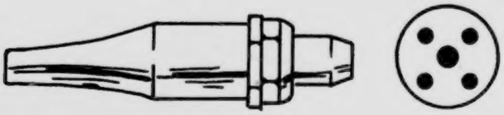
b. General purpose

c. Heavy preheat, heavy cutting

d. Medium preheat, gouging

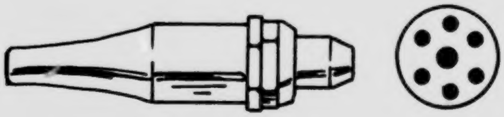
e. Medium preheat, light cutting

TYPICAL CUTTING TIPS AND ORIFICES



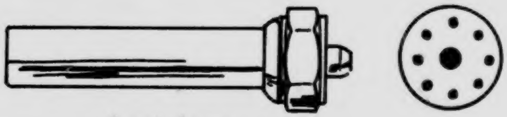
Acetylene

Light Preheat, Light Cutting



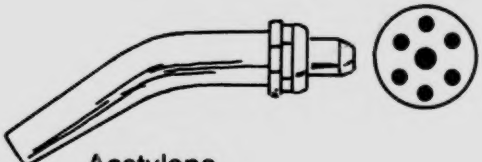
Acetylene

Medium Preheat, Light Cutting



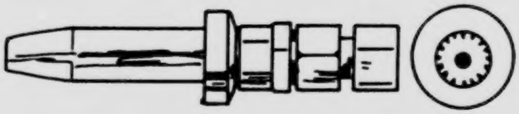
Acetylene

Heavy Preheat, Heavy Cutting



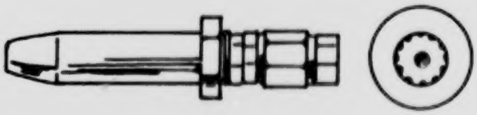
Acetylene

Medium Preheat, Gouging



Propane

General Purpose



Natural Gas (Methane)

General Purpose

CUTTING TIP CHART*

HO 8.2

	Regulator Pressure (psi)		
Metal Thickness	Oxygen	Acetylene	MAPP, Propane, and Natural Gas**
1/8"	10-15	3-5	10
1/4"	20-25	3-5	10
3/8"	25-30	4-6	10
1/2"	25-30	5-7	10
3/4"	35-40	5-7	10
1"	40-45	5-7	10
1 1/2"	45-50	5-7	10
2"	45-50	6-8	10

* The settings listed above are averages, based on a variety of cutting tips. Refer to the manufacturer's booklet to find exact settings required for the tip being used.

** The oxygen levels listed are for use with acetylene. When MAPP, propane, or natural gas are used, oxygen should be set approximately 5 psi higher than those listed above.

Demonstration Sheet 8.1: Making Beveled Cuts

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet for making beveled cuts with oxy-acetylene.

Tools and Equipment Needed:

1. Oxy-acetylene unit with cutting tip
2. Soapstone or chalk
3. Protective clothing
4. Welding goggles*
5. Safety glasses*
6. Pliers
7. Bucket of water

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate (1/4") - size to be determined by instructor

Precutting Procedure:

1. Clean all dirt, oil, and foreign materials from the surface of the metal.

2. Move all flammable materials from the work area.

3. Using the soapstone, mark a guide line on the metal to follow while cutting.

4. Properly light and adjust the torch to a neutral flame. Oxygen should be set at 20-25 psi and acetylene at 3-5 psi. (Refer to DS 2.1.)

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses should be worn at all other times.

5. Move the hoses away from the work area as much as possible. Make sure that the sparks from cutting do not hit the oxy-acetylene unit.

6. Assume a comfortable position where you will not be in line with sparks coming from the cut. Hold the torch with both hands for better control of the cut.

Cutting Procedure:

1. Hold the tip 1/8" from the surface of the metal to preheat the edge to be cut to a dull red. Hold the tip at a 60-degree angle to make the beveled cut.

2. Lift to 1/4" away, depress the oxygen lever, move to 1/8", and then move across the metal at a constant travel speed. The inner cone of the flame should be kept in contact with the metal.

3. Release the oxygen lever at the completion of the cut.

Postcutting Procedure:

1. Properly shut down the torch. (Refer to JS 2.1.)
2. Check the angle of the beveled cut for accuracy and appearance. If too much of an angle was cut, make another cut using less of a torch angle.
3. Cool the metal in water.
4. Assign JS 8.1 to be completed by students.

Demonstration Sheet 8.2: Cutting Holes With Oxy-Gas

Objective: At the completion of this demonstration sheet, the student will be ready to being the job sheet for cutting holes with oxy-gas.

Tools and Equipment Needed:

1. Oxy-acetylene unit with cutting tip
2. Soapstone or chalk
3. Protective clothing
4. Welding goggles*
5. Safety glasses*
6. Pliers
7. Bucket of water

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate (1/4") - size to be determined by instructor

Precutting Procedure:

1. Clean all dirt, oil, and foreign materials from the surface of the metal.

2. Move all flammable materials from the welding area.

3. Using the soapstone, draw two circles on the metal: one circle should be 1" in diameter, the other should be 1/2" inch in diameter.

4. Properly light and adjust the torch to a neutral flame. Oxygen should be set at 20-25 psi and acetylene at 3-5 psi.

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

5. Move the hoses away from the work area as much as possible. Make sure that the sparks from cutting do not hit the oxy-acetylene unit.

6. Assume a comfortable position where you will not be in line with sparks coming from the cut. Hold the torch with both hands for better control of the cut.

Cutting Procedure:

1. Move the tip of the torch to the center of the circle and preheat the metal to a dull red.

2. Slowly depress the oxygen lever; at the same time, tilt the torch 15 degrees from vertical and raise the tip approximately 1/2" to 5/8" above the surface of the metal.

NOTE: Tilting the torch allows the molten metal to be blown away from the operator, while raising the tip helps prevent slag from blowing back into the tip.

3. When the cut has penetrated the metal, return the torch to the vertical position and lower the tip to 1/4" from the surface of the metal.
4. Carefully cut inside the line of the circle, while holding the tip at a 90-degree angle.
5. When the first hole has been cut, move to the next circle. Use the same procedure to complete the next cut.

Postcutting Procedure:

1. Properly shut down the torch. (Refer to DS 2.1.)
2. Check the cuts for accuracy and appearance.
3. Cool the metal in a bucket of water.
4. Assign JS 8.2 to be completed by students.

Job Sheet 8.1: Making Beveled Cuts

Objective: At the completion of this job sheet, the student will be able to make beveled cuts with oxy-gas.

Tools and Equipment Needed:

1. Oxy-acetylene unit with cutting tip .
2. Soapstone or chalk
3. Protective clothing
4. Welding goggles*
5. Safety glasses*
6. Pliers
7. Bucket of water

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate (1/4") - size to be determined by instructor

Precutting Procedure:

1. Clean all dirt, oil, and foreign materials from the surface of the metal.

2. Move all flammable materials from the work area.

3. Using the soapstone, mark a guide line on the metal to follow while cutting.

4. Properly light and adjust the torch to a neutral flame. Oxygen should be set at 20-25 psi and acetylene at 3-5 psi.

   CAUTION: Welding goggles must be worn from the time the torch is lit until it is shut down. Safety glasses must be worn at all other times.

5. Move the hoses away from the work area as much as possible. Make sure that the sparks from cutting do not hit the oxy-acetylene unit.

6. Assume a comfortable position where you will not be in line with sparks coming from the cut. Hold the torch with both hands for better control of the cut.

Cutting Procedure:

1. Hold the tip 1/8" from the surface of the metal to preheat the edge to be cut to a dull red. Figure 8.1 illustrates the correct angle for making a 60-degree bevel cut.

2. Lift to 1/4" away, depress the oxygen lever, move to 1/8", and then move across the metal at a constant travel

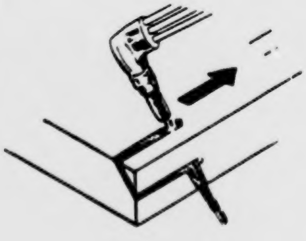


Figure 8.1

speed. The inner cone of the flame should be kept in contact with the metal.

3. After completing the cut, release the oxygen lever.

Postcutting Procedure:

1. Properly shut down the torch. (Refer to JS 2.1.)
2. Check the angle of the beveled cut for accuracy and appearance. If too much of an angle was cut, make another cut using less of a torch angle.
3. Cool the metal in water.
4. Turn in the metal to the instructor for grading.
5. Clean the work area.

Job Sheet 8.2: Cutting Holes With Oxy-Gas

Objective: At the completion of this job sheet, the student will be able to cut holes with oxy-gas.

Tools and Equipment Needed:

1. Oxy-acetylene unit with cutting tip
2. Soapstone or chalk
3. Protective clothing
4. Welding goggles*
5. Safety glasses*
6. Pliers
7. Bucket of water

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate (1/4") - size to be determined by instructor

Precutting Procedure:

1. Clean all dirt, oil, and foreign materials from the surface of the metal.

2. Move all flammable materials from the welding area.

3. Using the soapstone, draw two circles on the metal: one circle should be 1" in diameter, the other should be 1/2" inch in diameter.

4. Properly light and adjust the torch to a neutral flame. Oxygen should be set at 20-25 psi and acetylene at 3-5 psi.

5. Move the hoses away from the work area as much as possible. Make sure that the sparks from cutting do not hit the oxy-gas unit.

6. Assume a comfortable position where you will not be in line with sparks coming from the cut. Hold the torch with both hands for better control of the cut.

Cutting Procedure:

1. Move the tip of the torch to the center of the circle and preheat the metal to a dull red.

2. Slowly depress the oxygen lever; at the same time, tilt the torch 15 degrees from vertical and raise the tip approximately 1/2" to 5/8" above the surface of the metal, as illustrated in Figure 8.1.

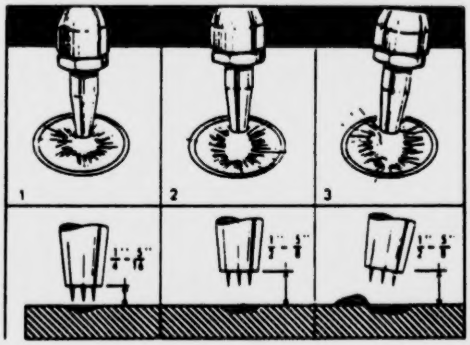


Figure 8.1

NOTE: Tilting the torch allows the molten metal to be blown away from the operator, while raising the tip helps prevent slag from blowing back into the tip.

3. When the cut has penetrated the metal, return the torch to the vertical position and lower the tip to 1/4" from the surface of the metal, as shown in Figure 8.2.

4. Carefully cut inside the line of the circle, while holding the tip at a 90-degree angle. (See Figure 8.2.)

5. When the first hole has been cut, move to the next circle. Follow the above procedure to cut the next circle.

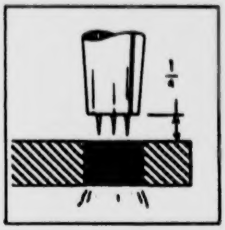


Figure 8.2

Postcutting Procedure:

1. Properly shut down the torch. (Refer to JS 2.1.)
2. Check the cuts for accuracy and appearance.
3. Cool the metal in a bucket of water.
4. Turn in the metal to the instructor for grading.
5. Clean the work area.

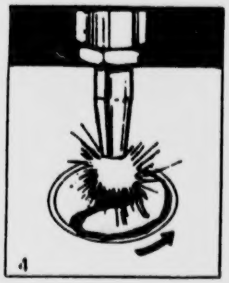


Figure 8.3

Lesson 9: Arc-Air and Plasma-Arc Cutting*

Objective: The student will be able to cut a piece of metal using arc-air and plasma-arc cutting processes.

Study Questions

1. **What is arc-air cutting?**
2. **What equipment is necessary for arc-air cutting?**
3. **What different types of cutting can be done with arc-air?**
4. **What are the advantages of arc-air cutting?**
5. **What is plasma-arc cutting?**
6. **What equipment is necessary for plasma-arc cutting?**
7. **What types of metal can be cut with plasma-arc?**
8. **What are the advantages of plasma-arc cutting?**
9. **What safety precautions should be observed for air-carbon arc and plasma-arc cutting?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. American Technical Publishers, Alsip, NY: 1986.
2. Transparency Master
    a) TM 9.1: Schematic of Plasma Arc Cutting
3. Demonstration Sheets
    a) DS 9.1: Arc-Air Cutting
    b) DS 9.2: Plasma-Arc Cutting
4. Job Sheets
    a) JS 9.1: Arc-Air Cutting
    b) JS 9.2: Plasma-Arc Cutting

* Plasma-arc cutting is not listed on the competency profile for Agricultural Construction. If this skill is taught, it should be added in one of the blanks provided on the profile.

Lesson 9: Arc-Air and Plasma-Arc Cutting

TEACHING PROCEDURES

A. Review

Review Unit I, Lesson 1 of Agricultural Construction (Volume I) for safe use of the AC-DC welder. Also review and discuss the previous lessons regarding cutting metal with oxy-gas.

B. Motivation

Some shops do not have an oxy-gas cutting unit available for use. With the use of an available AC-DC arc welding machine, the cutting process can be accomplished. Show the students the different pieces of metal cut with arc-air and oxy-acetylene and let them decide which piece was cut with which method.

C. Assignment

D. Supervised study

E. Discussion

1. There are several methods that can be used to cut metal. Ask the students to cutting methods they have used in the shop. Discuss the arc-air cutting process as an alternative.

   What is arc-air cutting?

   a) In the arc-air cutting process, the metal is cut (melted) by the heat produced from the arc between a carbon electrode and the base metal.
   b) It is also called air-carbon arc cutting.
   c) No filler metal or shielding gas is used in arc-air.

2. In order to arc-air cut with an arc welder, special equipment must be added. Show students the equipment necessary to accomplish arc-air cutting.

   What equipment is necessary for arc-air cutting?

   a) Power supply (arc welder)
   b) Air supply
   c) Carbon electrodes
   d) Arc-air torch
   e) Ground cable with clamp

3. Ask the students to list the different types of cutting that can be accomplished using the arc-air torch. Show the students examples of each cutting process.

   What different types of cutting can be done with arc-air?

   a) Gouging
   b) All-purpose cutting

c) Washing
d) Beveling

4. Arc-air cutting has several advantages over other cutting methods. Ask the students to list advantages of using arc-air over other cutting methods.

What are the advantages of arc-air cutting?

a) Heat source is more steady.
b) A more even cut can be made.
c) An arc welding machine may be used with a small additional investment.

5. Plasma-arc cutting is regarded as one of the best and fastest methods for high speed cutting of non-ferrous metals and stainless steels. Ask the students to describe plasma-arc cutting.

What is plasma-arc cutting?

a) Plasma-arc cutting is a high speed cutting process using plasma. Plasma is a gas that is heated to a high temperature.
b) The tip of the electrode is located within the nozzle.
c) As the gas is heated, it is forced through the tip at a very high rate of speed.
d) The intense heat melts any metal and blows it out of the cut.

6. Special equipment is needed in order to cut metal with the plasma-arc process. Ask students to list the parts of equipment needed. Use TM 9.1 to illustrate the equipment used in plasma-arc cutting.

What equipment is necessary for plasma-arc cutting?

a) Rectifier - with an open circuit power source rating of 100 volts with direct current and straight polarity.
b) A control unit automatically controls the sequence of operations.
c) The tip of the electrode is located within the nozzle.
d) A gas source for heating.
e) Air pressure of 60 to 100 psi is necessary to perform the operation.

7. Ask the students to list the different types of metal which can be cut using plasma-arc. Show students examples of each.

What types of metal can be cut with plasma-arc?

a) Any non-ferrous metal
b) Stainless steel
c) Carbon steel

8. Based on the characteristics discussed in previous questions, ask students what the advantages would be for plasma-arc cutting.

What are the advantages of plasma-arc cutting?

a) Very high speed
b) Clean
c) Can be automated (However, small units which most teachers use are hand held.)

d) Can cut several pieces at a time or one after another
e) Equal quality to other operations
f) Economical to use when needing a lot of precise cuts

9. Safety precautions are very important to follow when arc-air or plasma-arc cutting. Discuss with students additional precautions that should be observed to prevent injury.

What are safety precautions should be observed for arc-air and plasma-arc cutting?

a) Observe all safety procedures for arc welding.
b) Be sure to wear the proper clothing and footwear, such as a welding cap, shop coat, or coveralls.
c) Most arc-air and plasma cutting operations require a No. 10 shade lens.
d) Leather gloves which are hole-free and dry are particularly important.
e) Since plasma can cut anything that conducts electricity, extremities (e.g., hands, fingers, toes) can be severely burned or injured if not protected.
f) All cuffs should be turned down to cover the wrists and feet.
g) Do not come into contact with the ground clamp while cutting.

F. Other activities

1. Check with area equipment/service dealers to see if there are any films available on arc-air cutting.

2. Make a bulletin board showing all the different methods available for cutting metal.

G. Conclusion

Arc-air cutting is one more available cutting process. This process is utilized in several manufacturing plants in agricultural and industrial businesses. Arc-air cutting equipment is used in combination with an arc welder and can be installed for a small investment. Plasma-arc cutting will provide a cut that is much smoother than oxy-gas or arc-air processes. It is an automatic or semi-automatic operation that can be used when multiple cuts must be made identically or when a clean cut is desired.

H. Competency

Perform cutting with arc-air.

*Only arc-air cutting is listed on the Agricultural Construction competency list. An additional competency for plasma-arc cutting may be added in the blank space at the end of the list.

I. Answers to Evaluation

1. e
2. d
3. a
4. Three of the following: high speed, clean, can be automated, can cut several pieces at one time, equal quality, economical.
5. Any non-ferrous metal, stainless steel, carbon steel
6. Three of the following: observe safety precautions, proper clothing, gloves, protect extremities, cuffs should cover feet and hands, do not touch ground clamp

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ________________

Lesson 9: Arc-Air and Plasma-Arc Welding Date ________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a type of arc-air cutting?

   a. Gouging
   b. Cutting
   c. Washing
   d. Beveling
   e. Scrubbing

2. Which of the following is not necessary for arc-air cutting?

   a. AC or DC welder
   b. Electrode holder
   c. Carbon graphite rod
   d. Oxygen cylinder
   e. Air compressor

3. How does arc-air differ from other cutting processes?

   a. Uses no filler metal or shielding gas
   b. Uses compressed nitrogen
   c. Uses special fillers
   d. Uses carbon electrode and filler
   e. Uses argon gas

Complete the following short answer questions.

4. What are three advantages of plasma-arc cutting?

   a.

   b.

   c.

5. What are three types of metal that can be cut with plasma-arc?

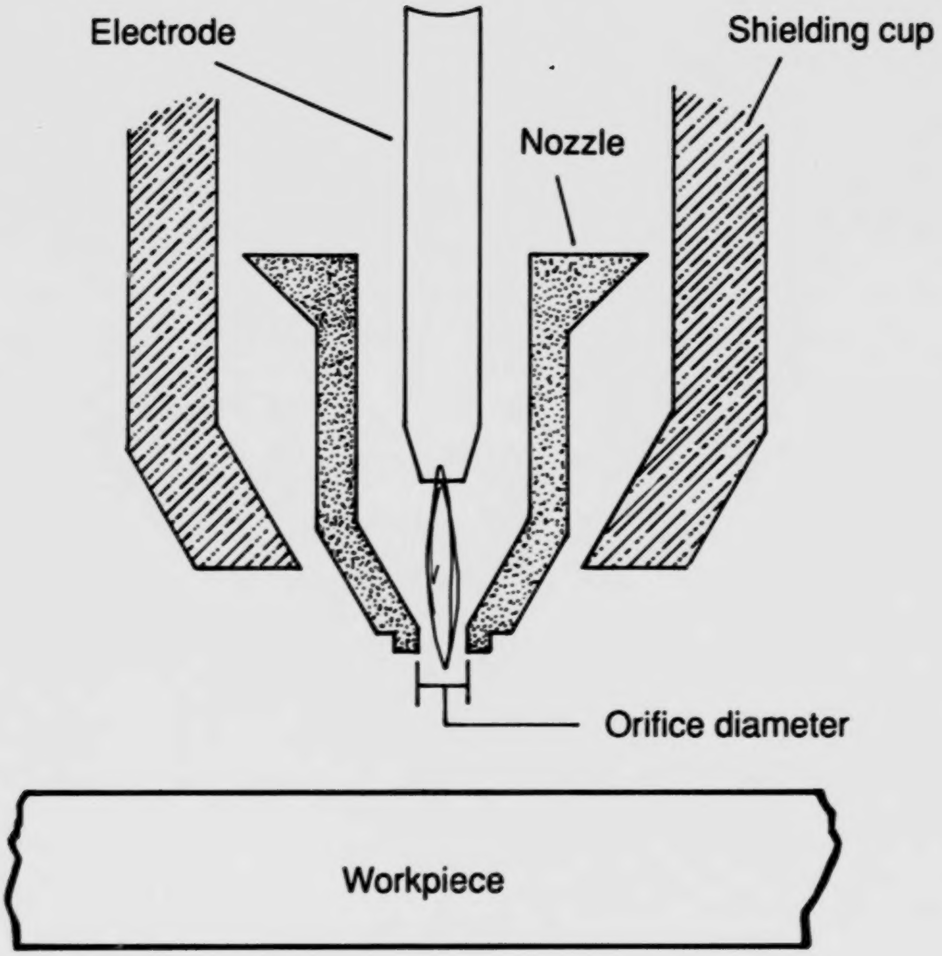
   a.

   b.

   c.

6. What are three safety precautions to follow when plasma-arc cutting?

SCHEMATIC OF PLASMA-ARC CUTTING


Electrode
Shielding cup
Nozzle
Orifice diameter
Workpiece

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Demonstration Sheet 9.1: Arc-Air Cutting

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on cutting metal using the arc-air cutting process.

Tools and Equipment Needed:

1. Arc welder
2. Arc-air electrode holder
3. Compressed air supply with regulator
4. Air hose
5. Chipping hammer
6. Protective clothing
7. Safety glasses*
8. Welding helmet*

*CAUTION: Welding helmets and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate - size to be determined by the instructor
2. Arc-air cutting electrode

Precutting Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.

2. Remove all flammable materials from the work area. Provide proper ventilation.

3. Expose the air and power connections by pushing back the insulated boot on the air-arc electrode holder.

4. Attach the electrode holder to the power assembly. The air hose should be attached to the air hose connection. Replace the insulated boot over the air and power connections.

5. Attach the regulator to the compressed air supply and attach the air hose to the regulator.

   CAUTION: Do not use oxygen as the compressed air supply, since it is flammable.

6. Adjust the regulator to 60-100 psi. Spray air on a piece of metal to make sure it is moisture free. If moisture collects on the metal, the compressed air supply should be checked.

7. Insert the electrode into the jaws of the electrode holder, with no more than 6" of electrode extending in front of the air jets. Don't burn the electrode past the 2" length.

8. Attach the ground clamp to the workpiece.

9. Set the welder to DC reverse polarity. Adjust the amperage according to the electrode diameter.

Cutting Procedure:

1. Position the air jets between the electrode and the metal if the metal is 1/2" thick or less. If the metal is more than 1/2" thick, position the electrode between the air jets and the base metal.

2. The electrode should be positioned at a 90-degree work angle and a 45-degree travel angle away from the direction of travel.

3. Turn the machine on.

4. Turn on the air jet with the air valve located on the electrode holder. Strike an arc and swing the electrode in and out of the metal without breaking the arc.

5. Move the electrode in the direction of the cut just as the arc first exits the base metal's back side. Continue with a slight swinging motion for the entire length.

6. Finish the cut. Turn off the air jet by using the air valve on the electrode. Place the electrode holder in a safe position where it cannot spark.

Postcutting Procedure:

1. Turn off the air supply and the machine. Remove the arc-air electrode holder from the air hose.

2. Examine the cut for accuracy and appearance.

3. Assign JS 9.1 to be completed by students.

Demonstration Sheet 9.2: Plasma-Arc Cutting

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on cutting metal using the plasma-arc cutting process.

Tools and Equipment Needed:

1. Plasma power sources
2. Plasma torch and leads
3. Gases (as required by manufacturer)
4. Safety glasses*
5. Welding helmet*
6. Protective clothing
7. Straight-edge

*CAUTION: Welding helmets and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of ferrous or non-ferrous metal
2. Electrode

Precutting Procedure:

1. Connect the torch to the power source.
2. Attach gas lines from the machine to the required cylinder or gas line. (Some machines operate on compressed air while others require gases stored in cylinders or bulk storage tanks.)
3. Set the power level on the machine to the required level.
4. Set the regulators or flow meter to the required amount.
5. If applicable, attach the torch coolant lines to water or radiator sources.
6. Using a straight-edge, mark lines on the metal to be cut.
7. Align the straight-edge with the mark so the plasma torch will cut evenly along the line.

Cutting Procedure:

1. Start the machine and move along the side of the straight-edge for the complete length of the desired cut.
2. Stop the cutting action and position the tip of the plasma torch in a safe direction.

Postcutting Procedure:

1. Turn the machine off.

2. Check the cut for slag, burn-through, and accuracy.

3. Assign JS 9.2 to be completed for students.

Job Sheet 9.1: Arc-Air Cutting

Objective: At the completion of this job sheet, the student will be able to cut metal using the arc-air cutting process.

Tools and Equipment Needed:

1. Arc welder
2. Arc-air electrode holder
3. Compressed air supply with regulator
4. Air hose
5. Chipping hammer
6. Protective clothing
7. Safety glasses*
8. Welding helmet*

*CAUTION: Welding helmet and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Mild steel plate - size to be determined by the instructor
2. Arc-air cutting electrode

Precutting Procedure:

1. Clean all dirt, grease, and foreign materials from the surface of the metal.
2. Remove all flammable materials from the work area. Provide proper ventilation.
3. Expose the air and power connections by pushing back the insulated boot on the air-arc electrode holder, as illustrated in Figure 9.1.

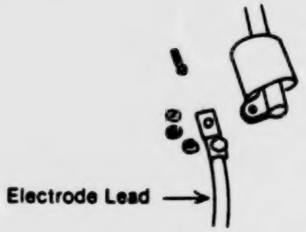


Figure 9.1

4. Attach the electrode holder to the power assembly. The air hose should be attached to the air hose connection. Replace the insulated boot over the air and power connections. See Figure 9.2.

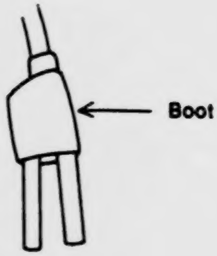


Figure 9.2

5. Attach the regulator to the compressed air supply and attach the air hose to the regulator.

   CAUTION: Do not use oxygen as the compressed air supply, since it is flammable.

6. Adjust the regulator to 60-100 psi. Spray air on a piece of metal to make sure it is moisture free. If moisture collects on the metal, the compressed air supply should be checked.

7. Insert the electrode into the electrode holder and adjust the amperage, based on the diameter of the electrode.

8. Attach the ground clamp to the workpiece and turn on the welding machine.

Cutting Procedure:

1. Place the electrode in the jaws of the electrode holder.

2. Position the air jets between the electrode and the metal if the metal is 1/2" thick or less. If the base metal is more than 1/2" thick, position the electrode between the air jets and the base metal.

3. Hold the electrode at a 90-degree work angle, as shown in Figure 9.3, and a 45-degree travel angle away from the direction of travel, as illustrated in Figure 9.4.

4. Turn on the air jet with the air valve located on the electrode holder.

5. Strike an arc and swing the electrode in and out of the metal without breaking the arc.

6. Move the electrode in the direction of the cut just as the arc first exits the base metal's back side. Continue with a slight swinging motion for the entire length.

7. Finish the cut. Turn off the jet air by using the air valve on the electrode. Place the electrode holder in a safe position where it cannot spark.

8. Turn off the air supply and the welding machine. Remove the arc-air electrode holder from the air hose.

9. Turn in the weld to the instructor for grading.

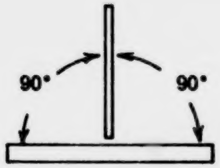


Figure 9.3

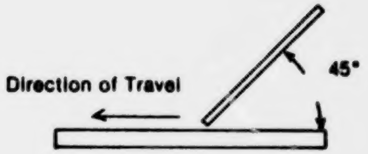


Figure 9.4

130

Job Sheet 9.2: Plasma-Arc Cutting

Objective: At the completion of this job sheet, the student will be able to cut metal using the plasma-arc cutting process.

Tools and Equipment Needed:

1. Plasma power sources
2. Plasma torch and leads
3. Gases (as required by manufacturer)
4. Safety glasses*
5. Welding helmet*
6. Protective clothing
7. Straight-edge

*CAUTION: Welding helmet and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of ferrous or non-ferrous metal

Precutting Procedure:

1. Connect the torch to the power source.
2. Attach the gas lines from the machine to the required cylinder or gas line. (Some machines operate on compressed air while others require gases stored in cylinders or bulk storage tanks.)
3. Set the power level on the machine to the required level.
4. Set the regulators or flow meter to the required amount.
5. If applicable, attach the torch coolant lines to water or radiator sources.
6. Using a straight-edge, mark several lines on the metal to be cut.
7. Align the straight-edge with the mark so the plasma torch will cut evenly along the line.

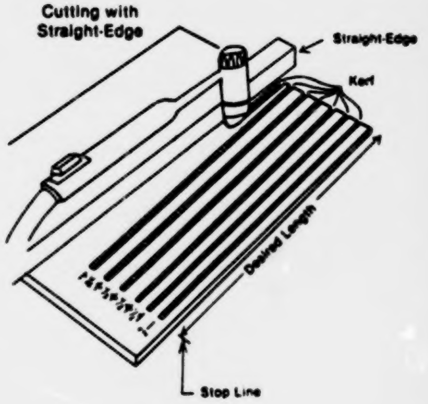


Figure 9.1

Cutting Procedure:

1. Start the machine and move along the side of the straight-edge for the complete length of the desired cut, as shown in Figure 9.1.

2. Stop the cutting action and position the tip of the plasma torch in a safe direction. Repeat the cutting procedure for each line.

Postcutting Procedure:

1. Turn the machine off.

2. Examine the cut for accuracy and appearance.

3. Turn in the weld to the instructor for grading.

4. Clean the work area.

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES

Lesson 10: Cutting with a Motorized Torch

Objective: The student will be able to properly cut metal using the motorized torch.

Study Questions

1. **What is the difference between manual and machine cutting?**
2. **What types of machines are available for oxygen cutting?**
3. **When can a cutting machine be used?**
4. **What variations are there in machine cutting?**
5. **What factors affect the quality of a machine cut?**

Reference

1. Handout
    a) HO 10.1: Cutting with a Motorized Torch

Lesson 10: Cutting with a Motorized Torch

TEACHING PROCEDURES

A. Review

Review the previous lesson on arc-air and plasma arc cutting.

B. Motivation

Many large companies cannot rely on one person to make the same cut on several thousand pieces. It is also not economical for many individuals to be cutting the same item due to differences that can occur in the work. Ask students how these problems can be alleviated. Tour a local manufacturing plant that has a machine cutting device in operation to show students the magnitude of this machine.

C. Assignment

D. Supervised study

E. Discussion

1. There is a drastic difference between manual cutting and machine cutting. Ask the students to list the differences between manual and machine cutting.

   What is the difference between manual and machine cutting?

   a) Manual cutting
      1) Hand held
      2) Can make adjustments
      3) Less accurate
      4) Relatively inexpensive
   b) Machine cutting
      1) Machine controlled
      2) Adjustments are difficult
      3) More accurate
      4) Expensive machine

2. Various types of machines are available for different jobs or sizes of jobs to be done. Discuss with students the various machines available to do the assorted jobs. If machines are in the shop, point them out.

   What types of machines are available for oxygen cutting?

   a) Tractor-type
   b) Hand-guided
   c) Pipe-beveling
   d) Shape-cutting

3. A cutting machine is a versatile machine used for economical and time-saving cutting. Ask students to list those times when a cutting machine should be used.

When can a cutting machine be used?

a) When cutting several pieces of the same dimension.
b) When needing precise cuts with many angles, shapes, etc.
c) When economical cutting is necessary.

4. Variations of cutting are important in economically accomplishing a given job. Ask students to name those types or variations of cutting that might be used.

What variations are there in machine cutting?

a) Stack cutting
b) Plate-edge preparation

5. The quality of cuts cannot be guaranteed even with the finest machine and the most precise control. Ask the students to list factors which would affect cutting quality.

What factors affect the quality of a machine cut?

a) Correct nozzle selection
b) Nozzle cleanliness
c) Preheat flame adjustment
d) Cutting speed

F. Other activities

1. Tour a manufacturing company close to your area to see what a cutting machine looks like, and how it actually cuts.

2. Contact area suppliers/salespeople and see if an in-lab demonstration could be set-up, after which the students could allowed to program a special cut of their own design.

3. Obtain available films, videotapes, etc. to show to the students.

G. Conclusion

The cutting process has been and continues to be revolutionized by the use of advanced metal cutting machines. The initial cost of the machine is high; however the machine is very economical if programmed and operated correctly. Understanding the methods of motorized cutting is essential to the future of metal work and cutting.

H. Competency

Cut using the motorized torch.

I. Answers to Evaluation

1. b
2. a
3. a
4. Machine: Accuracy, cutting is done by the machine
5. Manual: Can make adjustments, inexpensive

UNIT II - OXY-GAS AND OTHER CUTTING/WELDING PROCESSES Name ____________________

Lesson 10: Cutting with a Motorized Torch Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a type of oxygen cutting machine?

   a. Tractor-type
   b. Self-programming type
   c. Hand-guided type
   d. Pipe beveling type
   e. Shape-cutting type

2. Cutting machines are operated by which of the following methods?

   a. Guided on a track
   b. Self-propelled
   c. Battery operated
   d. Solar powered
   e. Gravitational pull

3. Which of the following does not affect the quality of the operation?

   a) Size of oxygen tanks
   b) Nozzle cleanliness
   c) Correct nozzle
   d) Cutting speed
   e) Preheat flame adjustment

Complete the following short answer questions.

4. What are two advantages of machine cutting?

   a.

   b.

5. What are two advantages of manual cutting?

   a.

   b.

CUTTING WITH A MOTORIZED TORCH

HO 10.1

Hand cutting with the oxy-acetylene torch is not the only option for cutting metal using the oxy-gas process. Machines have been developed that allow metal to be used without hand manipulation from the operator.

Manual versus Machine Cutting

Lessons 8 and 9 in this unit have required you to cut metal by hand using the oxy-gas, arc-air, and plasma-arc processes. In the manual process, the torch is held and controlled by the operator. Control of the torch allows adjustments to be made during the cutting process when necessary. Accuracy is sometimes less than perfect if the torch is controlled by hand. The equipment used in hand cutting is usually inexpensive. In the oxy-gas machine cutting process, the actual cutting is controlled by a machine. Accuracy is much greater with the machine cutting process. The operator must program into the machine the necessary instructions to perform the cut. If accurate instructions are given, an accurate cut will be made. A disadvantage to the machine cutting method is that adjustments are difficult to make once the cutting process begins. The cost of the equipment needed for machine cutting is generally very expensive.

Types of Machine Cutters

There are several types of machine cutters that cut with oxygen. The type of machine to use will vary depending on the type of cuts, location of cuts, and number of cuts.

Tractor-types - Tractor-type cutting machines almost always require set-up, alignment, and adjustment by the operator. The machine operates on tracks that move it along as cutting begins. Tractor-type cutters are generally only equipped for horizontal cutting, though some models, through the use of magnetic tracks, are able to cut in the vertical and overhead position. Tractor-type cutters are powered by a motor-driven carriage with governor-controlled speed. They generally are used to make square or beveled cuts, but can be modified with a radius rod to cut circles.

Figure 10.1 - Tractor-type

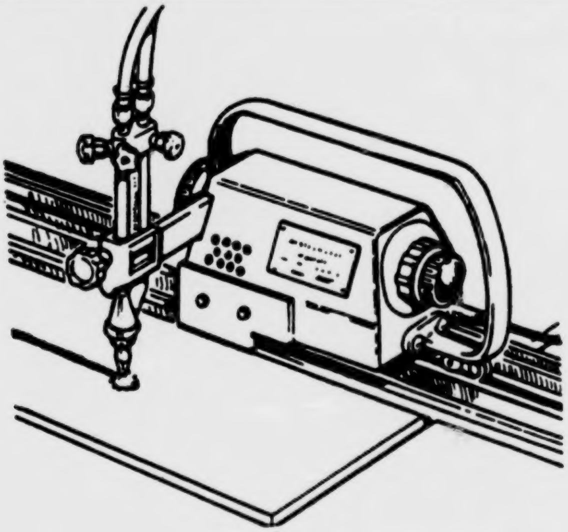
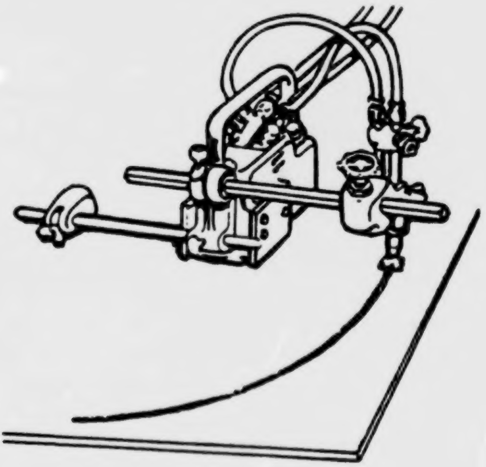


Figure 10.2 - Hand-guided



Hand-Guided Types - Hand-guided types will vary in design with one to three wheels and attachments for cutting straight lines, bevels, circles, and irregular shapes. Hand-guided machines can be used to cut horizontally or vertically and are adjustable to many steel forms, including rod and pipe. The cutting torch is centered in front of or beside a drive wheel. These machines are controlled by the operator, who oversees speed and direction of the cutting torch.

Pipe-Beveling Machines - Pipe-beveling machines are designed for cutting beveled angles, "T"'s, "Y"'s, and other connecting shapes of pipe. Pipe-beveling machines may be motorized or operated manually. They have a split horseshoe design that fits the inside or outside contour of the pipe and is then clamped into position for cutting. The torch holders have easy-to-read protractors for precise control of the cutting angle.

Figure 10.3 - Pipe-beveling

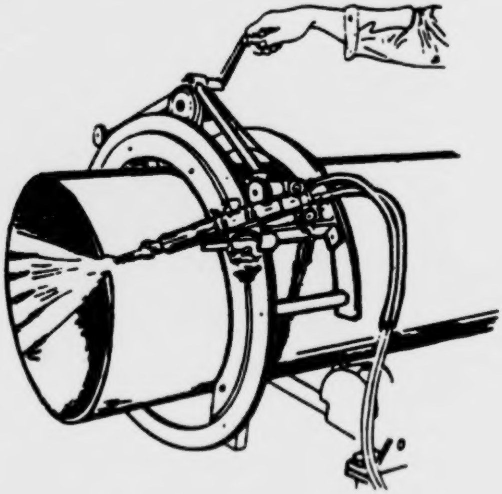
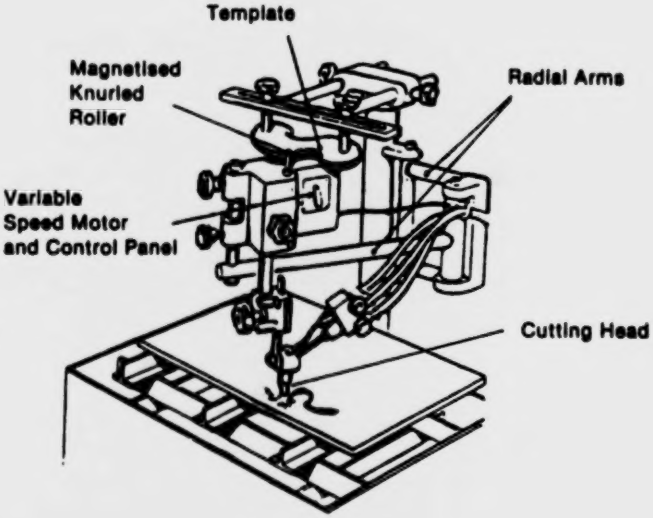


Figure 10.4 - Shape-cutting type


Template
Magnetised Knurled Roller
Radial Arms
Variable Speed Motor and Control Panel
Cutting Head

Shape-Cutting Machines - Shape-cutting machines are usually designed for specific job requirements where the cutting of multiple identical shapes contributes to high productivity. Shape-cutting machines can operate one of two ways. First, they can be used as tracing machines that use a photocell or electric eye to trace a pattern. Secondly, they may be operated by magnetic devices that follow a metal template. The gas torch is operated from a terminal or panel to provide precise operator control. The machines may be numerically programmed with a punched tape fed into a master control unit or digitally controlled with solid-state devices on a push-button control panel.

When to Use Cutting Machines

A cutting machine is a versatile machine used for economical and time-saving cutting. They are used when cutting several pieces of metal to the same dimensions. Accuracy will be much better if the pieces are cut by the machine, than if they had been cut by hand. Precise cuts can be made with the machine. If the correct information and instructions are given to the machine, the correct cut will be made. If a lot of cutting is to be done, machine cutting can be economical since it eliminates some of the waste of parts cut by hand that are not accurate.

Variations of Cutting

Variations of cutting are important in economically accomplishing a given job. Two variations of cutting can be done with machine cutting. Stack cutting is the first variation. Stack cutting is simply stacking multiple pieces of metal on top of each other and cutting all pieces at the same time. This method allows for several pieces to be cut to the exact same dimensions. The number of pieces that can be cut at one time will depend of the capacity of the machine. The second variation is plate-edge preparation. Plate-edge preparation is when a single piece of metal, pipe, or rod is cut to certain dimensions. The edges can be cut to the proper angle or length, depending on the directions given by the operator.

Quality of the Cut

The quality of the cut cannot be guaranteed even with the finest machine and the most precise control if proper steps are not taken. Several factors contribute to the quality of the cut. Correct nozzle selection is one of the most important factors to consider. If the incorrect nozzle is used for the type of gas being used or the type of metal being cut, a quality cut may not result. Nozzles should be kept clean at all times to insure that the right amount of heat is delivered to the area to be cut. When less heat is in the cut area, the quality of the cut will suffer. The metal must be properly heated before cutting can begin. If an incorrect preheat flame is used, the metal will not be ready for cutting and may result in a poor quality cut. The final factor to consider in the quality of the cut is the travel speed of the cutting machine. Metal must be preheated to the proper temperature before it will allow the flame to cut through it. If the cutting speed is too fast, the metal will not be ready to be cut, resulting in a poor quality cut.

Summary

Several advantages exist for the use of a cutting machine over hand cutting technique. If used and operated correctly, the cutting machine should provide the operator with a higher quality, more accurate cut than can be achieved with a hand cutting method.

Credits

"Welding - Module 3." University of Missouri-Columbia: Instructional Materials Laboratory, 1988.

UNIT III - WOODWORKING

GETTING READY FOR THIS UNIT

This unit builds on materials presented in the agricultural mechanics unit of the Agricultural Science I and II core curriculums. If the topic was discussed in the core curriculum, the information was not presented again, but additional information has been presented. If materials need to reviewed from Agricultural Science I or II, it is indicated in the lesson. Two lessons in particular (3 and 4) are strictly developed to apply the information presented in the core curriculums.

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Lesson 1–Common Woods in Agricultural Construction III-1
HO 1.1: Common Woods in Agricultural Construction
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HO 2.1: Wood Fasteners
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Lesson 4–Hand Woodworking Tools III-29
Lesson 5–Power Woodworking Tools III-31
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DS 5.2: Using a Router
DS 5.3: Using a Power Miter Box Saw
DS 5.4: Using a Reciprocating Saw
DS 5.5: Using a Scroll Saw
JS 5.1: Using a Shaper
JS 5.2: Using a Router
JS 5.3: Using a Power Miter Box Saw
JS 5.4: Using a Reciprocating Saw
JS 5.5: Using a Scroll Saw
Lesson 6–Preservatives III-61
HO 6.1: Treating Lumber

OBJECTIVES

1. The student will be able to properly select wood for use in agricultural construction projects.

2. The student will be able to select the appropriate fasteners for a specific job.

3. The student will be able to list the actual and nominal dimensions of common construction lumber.

4. The student will be able to use hand woodworking tools.

5. The student will be able to safely use power woodworking tools.

6. The student will be able to select the proper preservative for wood.

COMPETENCIES

1. Identify common woods used in agricultural construction.

2. Select the proper fastener for a specific job.

3. List the actual and nominal dimensions of common construction lumber.

4. Use hand woodworking tools.

5. Use power woodworking tools.

6. Select preservatives.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Select two pieces of wood to exhibit them to the class. One should be straight and free of knots, warps, etc. The second piece should contain several flaws. Ask the class to choose which of the pieces they would rather use when constructing a project. Discuss the reasons for choosing one board over the other board.

2. Select a project that has previously been constructed in the shop. Have each student write down all tools, fasteners, and preservatives that were used to construct the project. Have the class identify the types of wood used. Discuss why the specific type of wood was selected for the project. What if another type of wood was used? What effect would that have on the project's strength and durability?

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

    a) Agricultural Construction Volume II (Student Handouts). University of Missouri-Columbia: Instructional Materials Laboratory, 1989.

2. Teacher References

    a) "Agricultural Mechanics Unit," Agricultural Science I Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

    b) Burkybile, Carl. Selecting and Using Fasteners and Hardware, VAS 3052. Urbana, IL: Vocational Agriculture Service.

c) Cooper, Elmer L. Agricultural Mechanics: Fundamentals and Applications. Albany, NY: Delmar Publishers, Inc., 1987.

d) Espenschied, R. F. Using the Carpenters Square, VAS 3009a. Urbana, IL: Vocational Agriculture Service.

e) Groneman, Chris H. General Woodworking. Western Division: McGraw-Hill Book Company, 1982.

f) University of Missouri-Columbia: University Extension agricultural publications

1) Cutter, Bruce E. "Softwood Lumber Grades" (5053), 1984
2) Cutter, Bruce E. "Hardwood Lumber Grades" (5052), 1984
3) Pastoret, James. "Air Seasoning (Drying) of Wood" (5550), 1979
4) Pastoret, James. "Structural Design with Wood" (5560), 1980
5) Pastoret, James and Troy Klein. "Treated Wood Products Available in Missouri," (G5505), n.d.
6) Pastoret, James. "Use of Treated Wood" (5501), n.d.
7) Slusher, John P. "How to Measure Trees and Logs" (5050), 1985

g) Wagner, Willis H. and Clois E. Kicklighter. Modern Woodworking. South Holland, IL: The Goodheart-Willcox Co., Inc., 1986.

Agricultural Construction
Unit III - Woodworking
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N	**Woodworking**
				1. Identify common woods used in agricultural construction
				2. Select the proper fastener for a specific job
				3. List the actual and nominal dimensions of common construction lumber
▨	▨	▨	▨	4. Use hand woodworking tools
				a.
				b.
				c.
				d.
				e.
				f.
				g.
				h.
				i.
▨	▨	▨	▨	5. Use power woodworking tools
				a.
				b.
				c.
				d.
				e.
				f.
				g.
				h.
				i.
				6. Select preservatives

Other (specify)

ricultural Construction
Unit III - Woodworking

Class/Section: ____________

Students:	Identify common woods used in agricultural construction	Select the proper fastener for a specific job	List the actual and nominal dimensions of common construction lumber	Use hand woodworking tools	a.	b.	c.	d.	e.	f.	g.	h.	i.	Use power woodworking tools	a.	b.	c.	d.	e.	f.	g.	h.	i.	Select preservatives			

UNIT III - WOODWORKING

Lesson 1: Common Woods in Agricultural Construction

Objective: The student will be able to properly select wood for use in agricultural construction projects.

Study Questions

1. **What woods are commonly used for projects in agricultural construction?**
2. **How are logs milled?**
3. **How is lumber seasoned?**
4. **How is lumber graded?**
5. **How is lumber selected?**
6. **How is lumber quality maintained?**

Reference

1. Handout
    - a) HO 1.1: Common Woods in Agricultural Construction

Lesson 1: Common Woods in Agricultural Construction

TEACHING PROCEDURES

A. Review

Introduce the unit.

B. Motivation

Exhibit several different pieces of wood with varying degrees of quality (knots, warps, checks). Ask students to choose which of the pieces they would rather use to construct a project. Have them write down the reasons for choosing or not choosing a board. Several different species of wood could be used. Change the type of project to see if the students' choices change.

C. Assignment

D. Supervised study

E. Discussion

1. Woods are classified according to characteristics that the tree possesses. Lumber is classified according to the type of tree, not the hardness of the wood. Discuss the woods that are commonly used in agricultural construction.

   What woods are commonly used for projects in agricultural construction?

   a) Softwoods
      1) Cut from trees which do not shed their leaves (coniferous).
      2) Examples: pine, cedar, redwood, fir, hemlock
   b) Hardwood
      1) Cut from broad-leaved trees that drop their leaves in the fall (deciduous).
      2) Examples: oak, walnut, ash, birch, balsa, poplar, elm, sycamore, beech, cherry, hickory, maple

2. A log must go through many processes before it becomes usable as lumber. Discuss the processes used to mill logs into lumber.

   How are logs milled?

   a) Debarking
   b) Sawing
      1) Plain-sawed (flat-grained for softwoods) - Boards are cut parallel to the grain.
      2) Quarter-sawed (edge-grained for softwoods) - Boards are cut so that the growth rings are at 45° to 90° angles with the surface. This lumber is less likely to warp.
   c) Edging
   d) Trimming
   e) Planing

3. Lumber that is used before seasoning is likely to warp as it dries, thus deforming the project. Discuss the methods used to season lumber.

How is lumber seasoned?

a) Air drying - Lumber is stacked to allow circulating air to remove most of the moisture from the wood.
    1) Use "stickers" to separate the pieces and support the wood
    2) The wood will shrink 5-10 percent while drying.
    3) Rough cut before drying and surfaced to the correct size after drying.
    4) 45 - 90 days required to air dry in warm weather, depending on the thickness of the wood. Approximately twice as long during winter.

b) Kiln Dried - Lumber is dried in big ovens. (most commonly used method)
    1) Air volume, temperature, and humidity can be controlled.
    2) Fewer internal stresses, cracks, splits, and warps due to more uniform drying.
    3) Moisture will be reduced to 5 to 10 percent.
    4) Takes less time than air drying
    5) More expensive
    6) A predetermined moisture level can be achieved.
    7) Kills decay, fungi, and insects

4. Lumber is graded as it leaves the mill. The grade assigned to the lumber is an indication of the quality of the wood. Discuss the various grades of lumber and describe how the grades are determined.

How is lumber graded?

a) Based on location, size and placement of knots, slope of grain, manufacturing defects, wane, warp, stain, decay, and splits.

b) Softwood Grades
    1) Intended use
        (a) Construction - will be used in the same basic form in which it is graded.
        (b) Remanufacture lumber - if the original size, shape, and appearance will be significantly altered.
    2) Classification of construction lumber
        (a) Light framing - 2 to 4 inches thick, 4 inches wide; construction, standard, and utility grades
        (b) Structural light framing - 2 to 4 inches thick, 2 to 4 inches wide; select structural, 1, 2, and 3 grades
        (c) Studs - 2 to 4 inches thick, 2 to 4 inches wide; stud grade
        (d) Structural joists and planks - 2 to 4 inches wide, 6 inches and wider; select structural 1, 2, and 3 grades
        (e) Appearance framing - 2 to 4 inches thick, 2 to 4 inches wide; appearance grade

c) Hardwood Grades
    1) Based on the number, size, and location of defects in the wood.
    2) Six grades
        a) Firsts and seconds (FAS) - 6 inches or wider; 8 ft. to 16 ft. long; 83.3% minimum yield
        b) Selects - 4 inches or wider; 6 ft. to 16 ft. long; 83.3% minimum yield
        c) 1 Common - 3 inches or wider; 4 ft. to 16 ft. long; 66.6% minimum yield

d) 2 Common - 3 inches or wider; 4 ft. to 16 ft. long; 50% minimum yield
e) 3 A - 3 inches or wider; 4 ft. to 16 ft. long; 33.3% minimum yield
f) 3 B - 3 inches or wider; 4 ft. to 16 ft. long; 25% minimum yield

5. The quality of a project largely depends on the quality of the lumber used to construct the project. Once the type of project has been selected, several factors should be considered when selecting the lumber to be used in constructing the project. Discuss considerations for selecting lumber with the class.

How is lumber selected?

a) By the species and grade
b) Color and quality of finish desired
c) Physical characteristics (i.e., desired hardness, bending strength, compression strength)
d) Moisture content
e) Nail holding capacity
f) Degree of warp
g) Decay resistance
h) Size
i) Weight
j) Workability

6. Lumber should be properly stored after it is purchased in order to maintain the quality and appearance for which it was originally purchased. Discuss how to maintain lumber quality with the class.

How is lumber quality maintained?

a) Stack stored lumber so that air is allowed to circulate around it.
b) Cover the lumber stack to protect it from rain and sunlight which can cause it to warp.
c) Avoid storing lumber for extended periods of time.

F. Other activities

1. Prepare a sample board showing the various types of plywood and composite board.

2. Collect and mount samples of boards that illustrate the defects discussed.

3. Plan and construct an electrically operated wood identification panel. It should operate in such a way that when the correct name is matched with the wooden sample, a light will glow or a buzzer will sound.

G. Conclusion

In order to be able to produce a quality project, the knowledge of lumber and wood is necessary. Understanding the process in which a log is transformed into lumber will increase your understanding of factors to consider when selecting lumber for a project. Grades are assigned to lumber to inform the buyer of the quality of the lumber. Special care must be taken for proper storage, use, and handling of lumber.

H. Competency

Identify common woods used in agricultural construction.

I. Answers to Evaluation

1. c
2. a
3. c
4. e
5. b
6. e
7. e
8. air drying, kiln drying
9. stack to allow air to circulate, cover to protect, avoid storing for a long period of time
10. Should be three of the following: species and grade, color and quality of finish, physical characteristics, moisture content, nail holding capacity, degree of warp, decay resistance, size, weight, and workability.

Name ________________

Lesson 1: Common Woods in Agricultural Construction Date ________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Hardwood logs which are cut parallel to the grain are said to be _________.

   a) Quarter-sawed
   b) Half-sawed
   c) Plain-sawed
   d) Parallel-sawed
   e) Sliced

2. Softwood logs which are cut so that its growth rings are at 45° to 90° angles with the surface are said to be _________.

   a) Edge-grained
   b) Hack-sawed
   c) Plain-sawed
   d) Cross-sawed
   e) Perpendicular-sawed

3. Kiln-dried lumber will have a moisture content of _________.

   a) 3 to 5 percent
   b) 5 to 7 percent
   c) 5 to 10 percent
   d) 10 to 15 percent
   e) 15 to 20 percent

4. Air dried lumber will have a moisture content of _________.

   a) 3 to 5 percent
   b) 5 to 7 percent
   c) 7 to 10 percent
   d) 10 to 15 percent
   e) 15 to 20 percent

5. Which of the following is a softwood?

   a) Oak
   b) Redwood
   c) Walnut
   d) Maple
   e) Cherry

6. Which of the following is a hardwood?

   a) Redwood
   b) Pine
   c) Hemlock
   d) Cedar
   e) Cherry

7. Which of the following is a grade of hardwood?

   a. Grade A
   b. Premium
   c. Choice
   d. Dimensioned
   e. No. 1 Common

Complete the following short answer questions.

8. What are the two most common methods of drying lumber?

   a.

   b.

9. What are three ways of properly storing lumber?

   a.

   b.

   c.

10. What are three factors to consider when selecting lumber?

   a.

   b.

   c.

When constructing a project, an understanding of the processes used to harvest and season the wood is important. This knowledge will be helpful in determining the types of wood available and characteristics needed to determine which wood to use. Not all wood has the same characteristics. Some woods are more suited for some applications than others. A clear understanding of the way in which woods are classified will assist you in constructing a durable and quality project.

Common Woods in Agricultural Construction

Wood is classified according to characteristics of the tree from which it is milled. Trees are divided into two broad categories: softwoods and hardwoods. Softwood lumber is cut from trees which do not shed their leaves in the fall. These are referred to as coniferous trees. Pine, cedar, redwood, fir, and hemlock are all examples of coniferous trees. Hardwood lumber is cut from broad-leaved trees that drop their leaves in the fall. These trees are referred to as deciduous trees. Oak, walnut, ash, birch, balsa, poplar, elm, sycamore, beech, cherry, hickory, and maple are all examples of deciduous trees.

Milling Logs

A log must go through many processes before it becomes usable as lumber. It must be debarked, sawed, edged, trimmed, and planed to make a board of the correct dimension that can be used in project construction.

The log is debarked before the lumber is cut. Debarking removes the bark from the log, as well as foreign material, such as dirt and rocks. Once the bark is removed, the log is sawed into boards. The log may be plain-sawed (flat-grained for softwoods) or quarter-sawed (edge-grained for softwoods), depending on the type of wood and the angle to the grain in which the cut is made. If a log is plain-sawed, the boards are cut parallel to the grain, as shown in Figure 1.1. Plain-sawing is faster than quarter-sawing and yields more lumber due to less waste from cutting. When quarter-sawing logs, the boards are cut so that the growth rings are at 45° to 90° angles with the surface, as illustrated in Figure 1.2. Quarter-sawing provides a prettier grain pattern than a plain-sawed board. The durability of the board is increased and makes it more resistant to wear. Boards that are quarter-sawn are less apt to warp, shrink, and swell than boards that are plain-sawed.

Figure 1.1

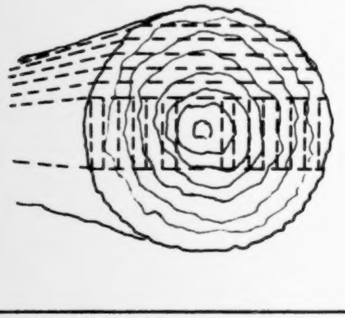
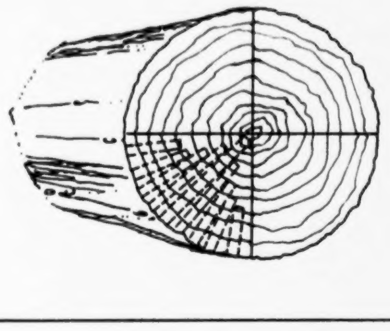


Figure 1.2



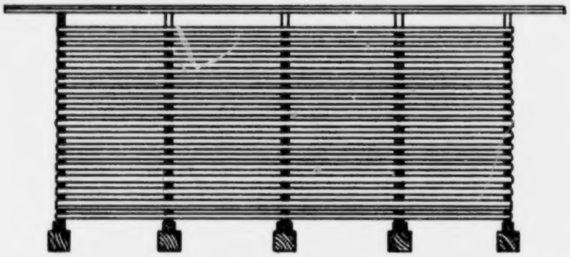
Once the boards have been sawn from the log, they are run through an edger which cuts the board to the desired width, leaving straight, parallel edges on the boards. The boards are then put through a trimmer which squares the end. Finally, the board is put through a planer which smoothes the surface of the board and planes it to the correct thickness.

Seasoning Lumber

Seasoned lumber means that the lumber is allowed to dry out by reducing the moisture level, either by natural or manufacturing processes. Seasoning of lumber is important since lumber that is used before seasoning is more likely to warp as it dries, thus deforming the project. Green lumber is lumber that is freshly cut from a log that has not had adequate time to dry out. Excessive moisture will need to be removed before it can be used. The moisture content of hardwoods must be reduced to 7-10 percent to prevent cracking and warping. There are two basic methods of seasoning lumber.

Air drying - Air drying allows air to circulate around the stacked lumber to remove some of the moisture from the wood. In air drying, all surfaces are exposed to the air by using "stickers" to separate the pieces. Stickers are also used to support the wood so that the lumber will not warp while it is drying, as shown in Figure 1.3. The boards should not be surfaced to the correct size before drying since the wood will shrink 5-10 percent while drying. Air drying generally takes 45 to 90 days during warm weather to reach the desired moisture level (15-20 percent), depending on the thickness of the wood. If the lumber is dried during the winter months, allow about twice as long.

Figure 1.3



Kiln Drying - Kiln drying is the most common method of drying wood. Big ovens are used to remove the moisture from the lumber. Moisture levels are generally reduced to 5 - 10 percent during kiln drying. There are several advantages to kiln drying over air drying. Air volume, temperature, and humidity can be controlled, allowing a predetermined moisture level to be achieved. Fewer internal stresses, cracks, splits, and warps occur due to more uniform drying of the lumber. Kiln drying takes less time than air drying and is more expensive. Decay, fungi, and insects can be eliminated by the temperature used in kiln drying.

Grading Lumber

Lumber is graded as it leaves the mill. The grade assigned to the lumber is an indication of the quality of the wood. Grade specifications are determined by lumber associations to inform the buyer of the quality of the wood being purchased. They are based on location, size and placement of knots, slope of grain, manufacturing defects, wane, warp, stain, decay, and splits that occur in the wood.

Softwood Grades - Softwood grades are determined according to the intended use of the lumber and its classification. The intended use is separated into two categories: construction lumber and remanufacture lumber. Construction lumber will be used in the same basic form in which it is graded, while the shape of remanufacture lumber will be changed. Construction lumber can be purchased that may or may not be stress graded. If the wood is stress graded, the stamp will tell the allowable stress that the board can endure. Table 1.1 shows the classifications of lumber and the possible grades that can be found in each class.

Table 1.1: Softwood Lumber Classes*

Class	Dimensions	Grade
Light framing	2 to 4 inches thick 4 inches wide	Construction Standard Utility
Structural light framing	2 to 4 inches thick 2 to 4 inches wide	Select Structural 1 2 3
Studs	2 to 4 inches thick 2 to 4 inches wide	Stud
Structural joists & planks	2 to 4 inches wide 6 inches and wider	Select Structural 1 2 3
Appearance framing	2 to 4 inches thick 2 to 4 inches wide	Appearance

*Adapted from Softwood Lumber Grades, Agricultural Guide 5053, University Extension

Hardwood Grades - Hardwood grades are based on the number, size, and location of defects in the wood. There are six grades of hardwood lumber. The National Hardwood Lumber Association has established minimum lengths and widths for the boards, minimum cutting sizes, and required clear area yields. The clear area yield is the amount of usable lumber when all defects have been removed. The figures listed in Table 1.2 below are minimums to qualify for a certain grade.

Table 1.2: Hardwood Lumber Grades*

Grade	Minimum Width	Minimum Length	Minimum Size of Cuttings	Minimum Clear Area Yield
Firsts and Seconds (FAS)	6" or wider	8 - 16 ft.	4" x 5 ft. or 3" x 7 ft.	83.3%
Selects	4" or wider	6 - 16 ft.	4" x 5 ft. or 3" x 7 ft.	83.3%
1 Common	3" or wider	4 - 16 ft.	4" x 2 ft. or 3" x 3 ft.	66.6%
2 Common	3" or wider	4 - 16 ft.	3" x 2 ft.	50%
3 A	3" or wider	4 - 16 ft.	3" x 2 ft.	33.3%
3 B	3" or wider	4 - 16 ft.	1 1/2" x 2 ft.	25%

*Adapted from Hardwood Lumber Grades, Agricultural Guide 5052, University Extension

Selecting Lumber

Several factors should be considered when selecting the lumber to be used in project construction. The type of project and its use will determine the type of lumber that can be used to construct the project. For example, a cattle feeder that is to be used outside should be made of a heavy wood that is durable in outside weather condition, such as wood. The following characteristics should be considered: species and grade, color and quality of finish desired, physical characteristics (i.e., hardness, bending strength, compression strength), moisture content, nail holding capacity, degree of warp, decay resistance, size, weight, and ease of working of the wood.

Maintaining Lumber Quality

Lumber should be properly stored after it is purchased in order to maintain the quality and appearance for which it was originally purchased. You should stack stored lumber so that air is allowed to circulate around it. Without proper air circulation, the lumber will absorb moisture, increasing the chances of warping. Cover the lumber stack to protect it from rain and sunlight which can cause it to warp. Avoid storing lumber for extended periods of time.

Summary

A working knowledge of the processes used to manufacture lumber, as well as how to store and maintain the quality of the lumber, will assist you in building a quality project that will last its expected service life.

Credits

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UNIT III - WOODWORKING

Lesson 2: Wood Fasteners

Objective: The student will be able to select the appropriate fasteners for a specific job.

Study Questions

1. **What types of catches and latches may be used?**
2. **What types of locks are using in woodworking?**
3. **What types of special fasteners are used to fasten wood?**

Reference

1. Handout
    - a) HO 2.1: Wood Fasteners

Lesson 2: Wood Fasteners

TEACHING PROCEDURES

A. Review

Review the previous lesson. Since fasteners discussed in the Agricultural Science I Core Curriculum will not be discussed in this lesson, it is suggested that the instructor review the Agricultural Science I materials.

B. Motivation

Display a variety of fasteners on a table in the classroom. Allow students to identify the fastener and its use. Give points to the student or group who identifies the most types of fasteners.

C. Assignment

D. Supervised study

E. Discussion

NOTE: Only the fasteners and finish hardware not discussed in the Agricultural Science I Core Curriculum will be discussed in this lesson. A review of the information found in the Agricultural Science I Core Curriculum will be helpful in selecting the appropriate fastener for agricultural project construction.

1. Projects that have hinged components require the use of a catch or latch to secure the parts in place. A wide array of types and styles of catches and latches is available. Discuss the examples listed below with the class, as well as any additional types. Ask students to identify situations where each would be useful.

   What types of catches and latches may be used?

   a) Eye hook and latch
   b) Door button
   c) Basket hasp
   d) Magnetic catch
   e) Roller catch
   f) Sliding bolt
   g) Chest latch

2. Locks are often used on projects to protect the contents or to prevent accidental opening. Discuss the types of locks listed below with the class and their application.

   What types of locks are used in woodworking?

   a) Deadbolt lock
   b) Cylinder key lock
   c) Padlock
   d) Combination lock

3. **Special application fasteners are often used in construction of wood projects. Discuss the following fasteners with students.**

   What types of special fasteners are used for wood?

   a) Corrugated fasteners
   b) Wood joiner

F. Other activities

1. Make a visual aid by mounting various nails, screws, and other metal fasteners on a framed panel. Be sure to carefully label each item.

2. Have students apply various fasteners on sample projects.

3. Give students a plastic bag which contains 10 fasteners and have them research the name and function of each fastener.

G. Conclusion

Selection of the appropriate fastener for use on your wood project will have a great impact on the final finished product. In order to have an attractive, properly finished product, a working knowledge of the various fasteners is necessary as well as the craftsmanship with which to use the fasteners. A properly finished product is one in which you can be proud.

H. Competency

Select the proper fastener for a specific job.

I. Answers to Evaluation

1. f
2. c
3. g
4. a
5. j
6. h
7. i
8. d
9. b
10. e
11. c
12. d
13. d
14. c

UNIT III - WOODWORKING

Name ____________________

Lesson 2: Wood Fasteners

Date ____________________

EVALUATION

Match the fasteners with the correct name.

______ 1. Deadbolt lock

______ 2. Corrugated fastener

______ 3. Combination lock

______ 4. Chest latch

______ 5. Eye hook and latch

______ 6. Door button

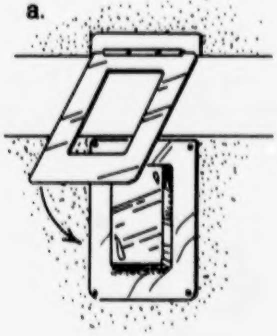
______ 7. Magnetic catch

______ 8. Roller catch

______ 9. Wood joiner

______ 10. Basket hasp

a.



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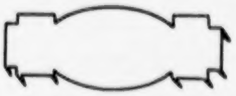

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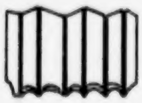

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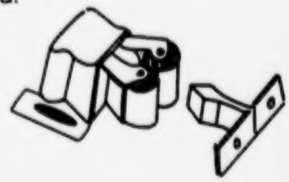

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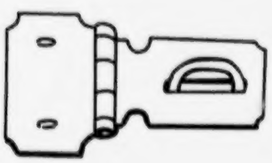

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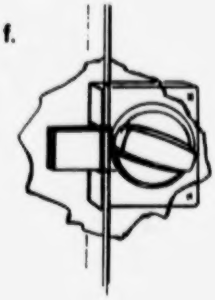

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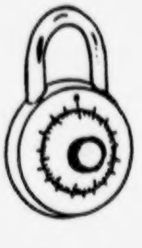

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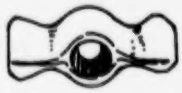

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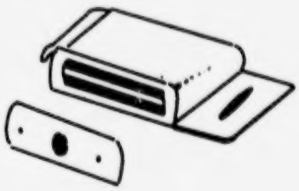
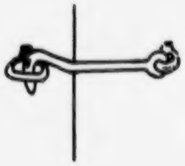


j.



Circle the letter that corresponds to the best answer.

11. John is building a new bed for his hay truck. What would be the best fastener to connect the boards to the metal frame of the truck?

    a. Screws
    b. Finishing nails
    c. Carriage bolts
    d. Glue
    e. Chest latch

12. Susan is building a show box to use at the county fair this summer. The box has a lid that lifts up to allow objects to be placed into the box. Which would be the best fastener for holding the lid in place when not open?

    a. Spike nail
    b. Glue
    c. Wood joiner
    d. Chest latch
    e. Corrugated fastener

13. Matt has just built a new tool cabinet for the shop at home. The doors keep falling open, thus creating the need for a fastener to keep them closed. Which of the following would work the best?

    a. Deadbolt lock
    b. Combination lock
    c. Basket hasp
    d. Door button
    e. Wood joiner

14. The Agricultural Structures class has just finished construction on a new plywood utility building. The building will be used for outside storage of valuable equipment. Which of the following should be installed on the door?

    a. Combination lock
    b. Padlock
    c. Deadbolt lock
    d. Basket hasp and padlock combination
    e. Cylinder key lock

Woodworking requires the use of a variety of fasteners and finish hardware for many different projects. When the project contains movable parts, the use of fasteners become necessary to make the project functional. The selection of the correct fastener for the project will allow the project to work as planned. Catches, latches, locks, and special fasteners will be discussed.

Catches and Latches

Projects that have hinged parts require the use of a catch or latch to secure the parts in place. A wide assortment of catches and latches available for woodworking projects. Selection of the correct latch or catch will depend on: the finish of the project, the style desired, the amount of money you are willing to spend, and the purpose for which the latch or catch will be used. The following paragraphs will discuss some of the types of catches and latches that are available for woodworking.

Eye hook and latch - An eye hook and latch are used to prevent a hinged part of a project from swinging open. They are most commonly used to secure doors. The strength of the eye hook and latch is minimal, since they are not designed to serve as a lock. Excessive pressure against the door on which they are used can cause the eye hooks to pull loose from the wood. Eye hooks and latches are installed by screwing the eye portion into the stationary part of the project. The latch contains a small eye bolt that is screwed into the moving part of the project. To use the eye hook and latch, insert the hook on the end of the latch into the eye hook to keep the movable part in place, as illustrated in Figure 2.1.

Figure 2.1

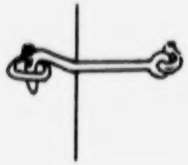
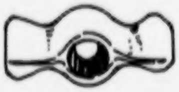


Figure 2.2



Door button - A door button (Figure 2.2) is not a type of lock, but it is used to hold doors closed. Door buttons are installed on the outside of the door facing with a nail or screw. When the door is in the closed position, the button is turned horizontally so that half of the button is covering the door facing and half is covering the door. When the button is in the horizontal position, the door will not swing open by itself. Like the eye hook and latch, the strength of the door button is limited and can be pulled out of the wood by excessive pressure.

Basket hasp - A basket hasp (Figure 2.3) is usually used in combination with a combination or padlock to secure movable parts of the project in place. The flat plate that is hinged on the top of the hasp is folded down over the plate that is mounted on the project. The shackle lock is inserted through the hole in the plate. As long as the lock is in place, the door or lid of the project cannot be opened.

Figure 2.3

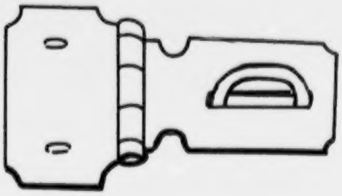
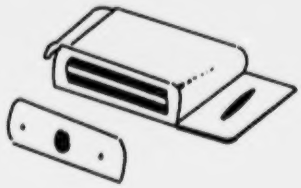


Figure 2.4



Magnetic catch - A magnetic catch (Figure 2.4) is often used on cabinet doors to keep them shut. A magnet is mounted inside of the cabinet frame and a flat metal plate is mounted on the inside of the cabinet door. When the cabinet door is closed, the magnet will bind with the metal plate to prevent the door from swinging open. When a small amount of pull is exerted on the cabinet door, the bond between the magnet and the metal will break and the cabinet door will open.

Roller catch - Roller catches are also used on cabinet doors to prevent the door from opening on its own. A bracket with two closely-spaced rollers is mounted inside the cabinet frame. When the cabinet door is closed, an expandable latch which is mounted on it, spreads the rollers apart and locks the door in place. When the door is pulled, the rollers will separate and release the latch, allowing the door to be opened.

Figure 2.5

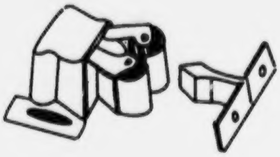
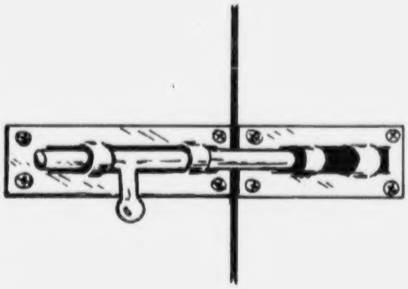


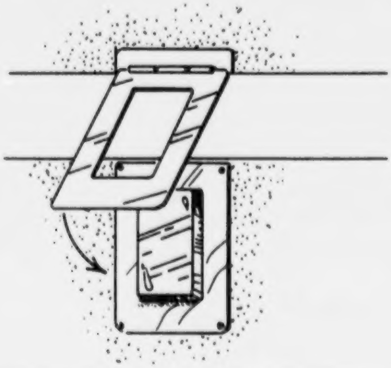
Figure 2.6



Sliding bolt - A sliding bolt works under the same principle as a deadbolt lock, only it does not go inside of the door facing. A sliding bolt is mounted on the inside surface of the door and the bracket which it fits into is mounted on the inside door facing. The bolt is guided by a bracket that keeps it in line with the bracket on the door facing. To operate the sliding bolt, grasp the knob on the bolt and slide it toward the door facing, as illustrated in Figure 2.6. When the bolt is in place, the door may not be opened without sliding the bolt out. The sliding bolt can only be operated from the inside and is usually used in combination with locks as an added safety feature.

Chest latch - Chest latches are used to prevent lids from opening when carrying a project by the handle. A hinged latch is lowered over a square catch and snapped into place, as shown in Figure 2.7. The tight fit of the latch over the catch prevents it from opening while the project is being carried. Some chest latches have locks built into the face that require a key to open.

Figure 2.7



Locks

Locks are often used on projects to protect the contents or to prevent accidental opening. Many times, locks will be used in combination with other fasteners or other types of locks. Following is a description of a few commonly used locks.

Deadbolt lock - Deadbolt locks are used on doors, generally in combination with a regular cylinder key lock. In a deadbolt lock, the bolt comes out of the body of the lock which is mounted on the door and rests in a slot cut in the door facing, as shown in Figure 2.8. The bolt is activated by turning a button on the inside or by using a key from the outside. Some deadbolts require a key to lock from the inside as well as the outside. Deadbolts are used for extra protection because they make break-ins difficult.

Figure 2.8

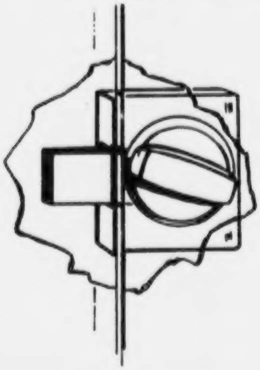
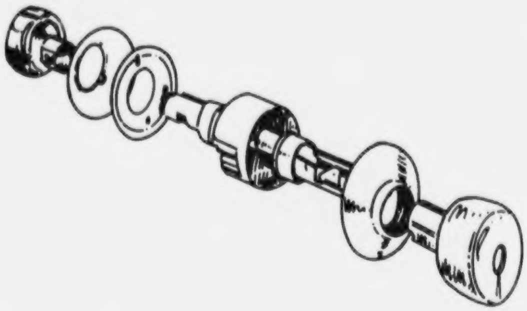


Figure 2.9



Cylinder key lock - Most doors are equipped with a regular cylinder lock. Most cylinder locks are adjustable and may be used on doors of different thicknesses. A groove and hole are chiseled into the door facing and a face plate is mounted, as shown in Figure 2.9. When the door is closed, a spring-loaded latch will catch in a slot that is cut into the face plate. By turning a button on the inside door handle, the latch will remain locked in place.

Padlock - Padlocks are used with other finish hardware, such as hasps, to prevent entry or opening of a door or movable part. A spring-loaded shackle with a notch on the end is inserted through the hole in the hasp mounted on the door facing and locked into place in the body of the lock, as shown in Figure 2.10. To release the shackle, a key is inserted into the cylinder of the lock and turned. Turning the cylinder will release the hook on the end of the shackle and unlock the padlock.

Figure 2.10

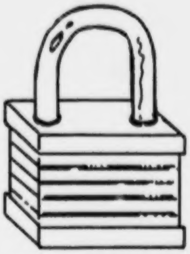
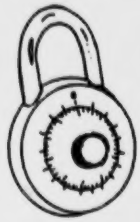


Figure 2.11



Combination lock - Combination locks are similar to padlocks except that turning the dial on the front with the correct series of numbers and the correct rotation of the dial will release the shackle and allow the combination lock to be removed. See Figure 2.11.

Special Fasteners

Special fasteners are often used in construction of wood projects when it is not possible to use other fasteners. A wide variety of fasteners are available for many different woodworking situations. The local hardware store usually carries many of these special fasteners or will be able to order them for you.

Corrugated fasteners - Corrugated fasteners are used to reinforce corner joints on projects. The sharp, beveled edge of the corrugated fastener is driven across the joint to prevent the joint from pulling apart. Corrugated fasteners are often used on picture frames. Corrugated fasteners are hammered below the face of the wood. See Figure 2.12.

Wood joiners - Wood joiners are similar in function to corrugated fasteners except that they have a solid face that is hammered flush with the surface of the wood. Sharp points on the bottom of the fastener are driven into the wood to hold the fastener in place and increase the holding power of the joint. Wood joiners are often used on glued joints to relieve some of the stress placed on the joint. See Figure 2.13.

Figure 2.12

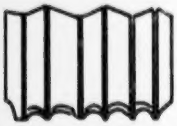


Figure 2.13

Credits

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Groneman, Chris H. General Woodworking. Western Division: McGraw-Hill Book Company, 1982.

Wagner, Willis H. and Clois E. Kicklighter. Modern Woodworking. South Holland: The Goodheart-Willcox Co., Inc., 1986.

Lesson 3: Dimensions of Construction Lumber

Objective: The student will be able to list the actual and nominal dimensions of common construction lumber.

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Assign a project from the Single Sheet plans to each student. Have each student prepare a list of the lumber required to build the project. Once the list has been completed, show the student the actual bill of materials for the plan. Have students check the accuracy of their list to the actual bill of materials.

C. Assignment

Review the Material Selection unit of the Agricultural Science II Core Curriculum for information on dimensioning construction lumber. Review actual versus dressed grades of lumber and plywood and the method used to figure board feet.

1. Identifying grades and uses of plywood and lumber
2. Calculating board feet
3. Developing a bill of materials

D. Supervised study

E. Discussion

F. Other activities

1. Have students figure board feet on several projects which need to have lumber ordered.

2. Ask a local construction company owner/manager to discuss the importance of understanding dimensions of construction lumber.

3. Tour a local lumber yard.

G. Conclusion

It is important to know how to determine the actual size of construction lumber by developing a bill of materials for a project. Knowing how lumber is graded and how to select the proper grade is essential in constructing a quality project with a minimum of waste; therefore, reducing cost. Knowing how lumber is sized will assist in ordering and receiving the proper materials to construct a project.

H. Competency

List the actual and nominal dimensions of common construction lumber.

I. Evaluation

Evaluation for this lesson will be based on the student's ability to identify lumber dimensions and grades.

UNIT III - WOODWORKING

Lesson 4: Hand Woodworking Tools

Objective: The student will be able to use hand woodworking tools.

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Display a variety of hand woodworking tools on the tables in the classroom. Divide students into small groups. Award bonus points or give a prize to the group that identifies the name and uses of the most tools.

C. Assignment

Review the following hand tools which were discussed in the woodworking unit of the Agricultural Science I Core Curriculum. Stress the safety procedures that should be followed when each of these tools are used. It may be necessary to teach all or a portion of the material from the Agricultural Science I unit, based on students' needs.

1. Saws
2. Squares
3. Marking gauge
4. Chalk line
5. Levels
6. Bits
7. Hand drill
8. Chisels
9. Planes
10. T bevel
11. Dividers
12. Plumb bob
13. Tape measure
14. Bit brace
15. Depth gauge
16. Wheel dresser

D. Supervised study

E. Discussion

Discuss additional hand tools located in your shop that were not covered in Ag Science I. Provide a demonstration for each tool and discuss safety precautions with students.

F. Other activities

1. Arrange to show as many films as possible regarding safe hand tool operation.

2. Make a display board with pictures of all hand woodworking tools and label them according to tool and job.

3. Have students identify the hand tools that were required to construct a project(s) in the shop.

G. Conclusion

The correct use of hand tools in woodworking will improve the quality of the project being constructed. If tools are carefully used and maintained, they will remain in good working condition for a long time. Safety should always be a consideration when using hand tools to prevent injury to yourself or others in the shop area.

H. Competency

Use hand woodworking tools.

I. Evaluation

The student's ability to use each of the tools listed above will be the evaluation for this competency. Additional tools discussed should be recorded in the blanks on the competency profile.

UNIT III - WOODWORKING

Lesson 5: Power Woodworking Tools

Objective: The student will be able to safely use power woodworking tools.

Study Questions

1. **What general safety precautions should be used for power woodworking tools?**
2. **When is a shaper used in woodworking?**
3. **When is a router used in woodworking?**
4. **When is a power miter box saw used in woodworking?**
5. **When is a reciprocating saw used in woodworking?**
6. **When is a scroll saw used in woodworking?**
7. **When is a pneumatic nailer used in woodworking?**

References

1. Handout
    - a) HO 5.1: Power Woodworking Tools
2. Demonstration Sheets
    - a) DS 5.1: Using a Shaper
    - b) DS 5.2: Using a Router
    - c) DS 5.3: Using a Power Miter Box Saw
    - d) DS 5.4: Using a Reciprocating Saw
    - e) DS 5.5: Using a Scroll Saw
3. Job Sheets
    - a) JS 5.1: Using a Shaper
    - b) JS 5.2: Using a Router
    - c) JS 5.3: Using a Power Miter Box Saw
    - d) JS 5.4: Using a Reciprocating Saw
    - e) JS 5.5: Using a Scroll Saw

Lesson 5: Power Woodworking Tools

TEACHING PROCEDURES

A. Review

Review the previous lesson. Power woodworking tools in the Agricultural Science I and II Core Curriculums should be reviewed since they are not covered in this lesson.

B. Motivation

Being able to safely use power tools is an important part of woodworking. Encourage students to develop a good attitude toward safety and the proper use of power tools. Show the students a safety film concerning power tool usage and discuss any past accidents that may have happened because of carelessness in the laboratory area.

C. Assignment

Power woodworking tools that are commonly used in the agricultural education shop that are not covered in the Ag Science I and II curriculum are discussed in this lesson. Demonstration sheets and job sheets are provided for each of the tools discussed, with the exception of pneumatic nailers. Due to the variety of types and styles available, each instructor should develop a demonstration sheet for the type available in their shop.

Student mastery of the competency for this lesson will be based on the student's ability to safely and correctly operate individual power tools. The competency profile sheet for the woodworking unit of Agricultural Construction provides blanks to fill in the type of power tool which the student has mastered. Some of the tools discussed in this lesson may not be available in your shop or you may have additional tools that are not covered. The profile sheet should list the tools that the student has mastered.

D. Supervised study

E. Discussion

1. Several general safety precautions are necessary for most operations performed in the shop area. The following general safety precautions should be observed when using power tools. Specific safety precautions are also included for individual tools. Discuss the following safety precautions with students.

What general safety precautions should be used for power woodworking tools?

a) Wear safety goggles (ANSI standard Z87.1).
b) Wear protective clothing.
c) Do not wear loose clothing.
d) Wear a hair net if you have long hair.
e) Follow manufacturer's recommendations for operating, adjusting, and repairing.
f) Disconnect the cord from the power source before making adjustments or repairs to the tool.
g) Do not use power tools for which instruction has not been given or mastery has not occurred.

h) All material being used should be properly clamped or supported.
i) Do not adjust power tools while they are connected to a power source.
j) Keep all guards in place.
k) Avoid getting fingers in the way of moving parts of the power tool.
l) Be sure the tool is adjusted properly before using.
m) Do not use a damaged tool. Report any damaged or malfunctioning tools to the instructor.
n) Keep the work area clear of obstacles that might interrupt the work of the tool or operator.

2. Discuss the use of a shaper with the class. DS 5.1 should be used to demonstrate the correct procedure for using a shaper. Discuss specific safety precautions for using a shaper. JS 5.1 should be used to evaluate student mastery.

When is a shaper used in woodworking?

a) Uses
    1) Shape edges of boards
    2) Shape moldings
    3) Cut special joints
b) Safety
    1) Only expose above the table the amount of cutter needed.
    2) Before starting the shaper, check all nuts for proper tightness. A loose nut could cause the cutter to fall off.
    3) Hands should be at least six inches from the cutter at all times.
    4) The fence should only be used on boards that are 10 inches or longer. A miter gauge should be used for shorter boards.
    5) Avoid using boards that have knots and cracks.

3. Discuss the use of a router with the class. DS 5.2 should be used to demonstrate the correct procedure for using a router. Discuss specific safety precautions for using a router. JS 5.2 should be used to evaluate student mastery.

When is a router used in woodworking?

a) Uses
    1) Shape edges
    2) Bevel, grooves
    3) Dovetail joints
    4) Rabbet cuts
b) Safety
    1) Disconnect the power source before making any adjustments to the router.
    2) Be sure the chuck is tight to prevent loosening of the bit during operation.
    3) All boards should be clamped to the table before routing.
    4) Hold the router firmly when turning the power on since the sudden power surge will cause the router to kick.
    5) Keep the power cord out of the path of the router.
    6) The bit should not be in contact with the wood when the router is turned on.
    7) Do not raise the router from the wood until the bit has stopped turning.
    8) To prevent dulling, do not set the router down on the bit.

4. Discuss the use of a power miter box saw with the class. DS 5.3 should be used to demonstrate the correct procedure for using a power miter box saw. Discuss specific

safety precautions for using a power miter box saw. JS 5.3 should be used to evaluate student mastery.

When is a power miter box saw used in woodworking?

a) Uses
    1) Straight cuts on narrow boards
    2) Crosscutting
b) Safety
    1) Disconnect the power source when inspecting or changing the blade.
    2) Keep all guards in place on the saw.
    3) Keep hands out of the way of the saw.
    4) Make sure the blade comes to a complete stop before removing the board from the table.
    5) Long boards should be supported by a stand or another person to prevent the board from kicking up into the saw.
    6) Do not cut oversized boards.
    7) Allow the saw to slowly return to its normal position.

5. Discuss the use of a reciprocating saw with the class. DS 5.4 should be used to demonstrate the correct procedure for using a reciprocating saw. Discuss specific safety precautions for using a reciprocating saw. JS 5.4 should be used to evaluate student mastery.

When is a reciprocating saw used in woodworking?

a) Uses
    1) Relief cuts
    2) Crosscutting
    3) Irregular cuts
    4) Inside curves
    5) Pocket cuts
b) Safety
    1) Disconnect the power source before inspecting or changing blades.
    2) Keep the cord away from the blade.
    3) Never point the saw at another person.
    4) Do not bind the blade.
    5) Do not force the blade into the wood.
    6) Turn the saw off immediately after the cut is made.
    7) Make sure the blade comes to a complete stop before laying the saw down.

6. Discuss the use of a scroll saw. DS 5.5 should be used to demonstrate the correct procedure for using a scroll saw. Discuss specific safety precautions for using a scroll saw. JS 5.5 should be used to evaluate student mastery.

When is a scroll saw used in woodworking?

a) Uses
    1) Small radius cuts
    2) Inside cuts
    3) Straight cuts
b) Safety
    1) Disconnect the saw from the power source when making adjustments.
    2) Keep belt guards in place at all times.

3) Check the blade for proper installation, with the teeth pointing down.
4) Keep fingers at least 4 inches from the blade at all times.
5) Keep the hold springs in place to prevent the wood from lifting on the upward stroke of the blade.

7. Discuss the use of a pneumatic nailer with the class, as well as the specific safety precautions for using a pneumatic nailer.

When is a pneumatic nailer used in woodworking?

a) Uses
   1) Applying framing and finish work
   2) Fastening wood
b) Safety
   1) Disconnect from the air source before loading or adjusting.
   2) NEVER point the nailer at anyone.
   3) Select the correct pressure setting based on the manufacturer's recommendation.
   4) Keep hands and feet away from the end of the nailer.
   5) Use only recommended fasteners for the style of nailer.
   6) Use the nailer only on materials that the fastener will not penetrate. (The fastener should not go through the material.)

F. Other activities

1. Since safety is so crucial in the woodworking shop, the instructor needs to correct any unsafe work practice immediately. To help students remember safe work habits, have them keep a log of unsafe work practices that they observe in class and the safe work practice that should have been observed. Also have students list possible outcomes of each poor work practice.

2. Arrange to show as many films as possible regarding the safe operation of any of the power woodworking tools listed.

G. Conclusion

The safe operation of power tools is critical to the safety of the user and others in the shop area. Individuals should not use tools for which they have not had instruction. All safety precautions should be observed to provide a safe working environment.

H. Competency

Use power woodworking tools.

I. Answers to Evaluation

Evaluation for this lesson will be based on the ability of the student to safely and correctly use the power tools discussed.

Safety Precautions for Power Tools

General safety precautions that apply to the use of most power woodworking tools are necessary for many operations performed in the shop area. Safety should be a primary concern for everyone who uses power tools since the chance of an accident is greatly increased by their use. The following precautions should be followed to reduce the risks of injury in the shop.

Safety goggles should be worn when working in the shop area to protect the eyes from foreign objects that might be thrown when using a power tool. Protective clothing is necessary to protect the body and street clothes from flying chips. Avoid wearing loose clothing since many power tools have moving parts that might wrap the loose ends of your clothing into them. Always read the owner's manual for equipment for special instructions on the use and safety of each tool. Follow the manufacturer's recommendations for operating, adjusting, and repairing power tools. Manufacturer's tools will vary. What may be appropriate use for one brand may not be appropriate for another. Methods of adjusting will also vary depending on the brand of tool.

Always disconnect the cord from the power source before making adjustments or repairs to the tool to prevent accidental starting of the tool. Do not use power tools with which you are not familiar or instruction has not been given. The torque created by the movement and turning of parts on power tools make it necessary that all materials being used be properly clamped or supported. When making adjustments to power tools, be sure the tool is disconnected from the power source. Never attempt to make adjustments while the machine is running. Keep all guards in place to prevent chips and sawdust from flying out, as well as to protect your body from moving parts in the tool. Avoid getting your fingers in the way of moving parts of the power tool. Check the tools to be sure they are in proper working order. If the tool is not working properly, it should be repaired or replaced before it is used. Report any damaged or malfunctioning tools to the instructor immediately. Keep the work area clear of obstacles, such as wood scraps and sawdust, that might interrupt the work of the tool or operator and increase the chances of injury.

Using a Shaper

A shaper has many applications in woodworking. It is used in agricultural construction to shape the edges of boards, to shape moldings, and to cut special joints on the edges of boards to increase their holding ability. A shaper uses a cutter to form the desired edge on the board. (See Figure 5.1.) There are several safety precautions that should be observed when using the shaper. Only the amount of cutter needed should be exposed above the table. All nuts should be tight to prevent the cutter from coming off during operation. To prevent injury to yourself when pushing the board through, you should keep your hands at least six inches from the cutter at all times. A fence should be used on boards that are ten inches or longer. If you are shaping a board that is less than ten inches, a miter gauge or guide block should be used to push the board. The fence, a miter gauge, or a guide block will allow you to keep your fingers a safe distance from the cutter. Avoid using boards that have knots and cracks. When the cutter hits a knot, it could throw a chunk of wood across the shop.

Figure 5.1

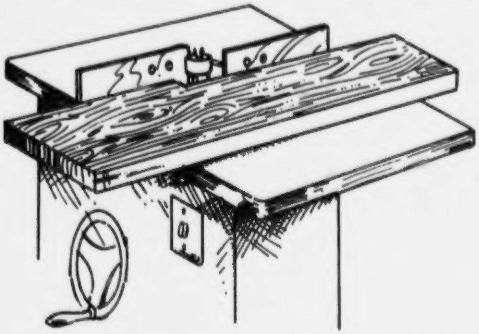
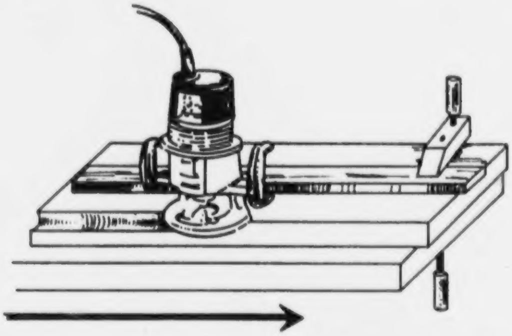


Figure 5.2



Using a Router

The router is similar to a shaper in its application for woodworking. In project construction, routers are used to shape edges on boards, to bevel edges, and to form grooves, dovetail joints, and rabbet cuts. (See Figure 5.2.) The router uses a bit to remove wood and form the desired edge. The type of bit used will depend on the edge or groove needed for the project. Always disconnect the power source before making any adjustments to the router since your hands are directly in line with the rotating shaft that turns the bit. An accidental bump of the switch could cause severe injuries to your hands if the cord is not unplugged. When changing the bit, be sure to tighten the chuck to prevent loosening of the bit during operation. Not only will damage to the project occur if the bit is loose, but the bit could be thrown across the shop and injure someone.

Since the router uses power to rotate the bit, all boards should be clamped to the table before routing. Clamping boards will not only hold the board still for more precise cuts, but it will also prevent the wood from spinning as a result of the extreme torque created by the rotation of the shaft on the router. When using the router, several considerations should be made to prevent injury. Hold the router firmly when turning the power on since the sudden power surge will cause the router to kick. Keep the power cord out of the path of the router to prevent electrical shock. The bit should not be in contact with the wood when the router is turned on. The base of the router should be rested on the edge of the board to be routed, without the bit contacting the wood. When finished, do not raise the router from the wood until the bit has stopped turning. To prevent dulling the tip, do not set the router down on the bit.

Using a Power Miter Box Saw

A power miter box saw is similar to a circular saw, except that it is permanently mounted. (See Figure 5.3.) The power miter box saw is used for crosscutting and making straight cuts on narrow boards. Always disconnect the power source when inspecting or changing the blade to prevent accidental starting of the saw. Keep all guards in place on the saw to prevent injury to yourself or others in the area. Keep your hands out of the path of the saw blade. You should allow the blade to come to a complete stop before removing the board from the saw table. Long boards should be supported by a stand or another person to prevent them from kicking up into the saw. Do not cut oversized boards that are wider than the maximum that can be cut by the saw. When the cut is finished, allow the saw to slowly return to its normal position. Since the saw is spring loaded, do not completely release the handle of the saw or damage could occur to the saw.

Figure 5.3

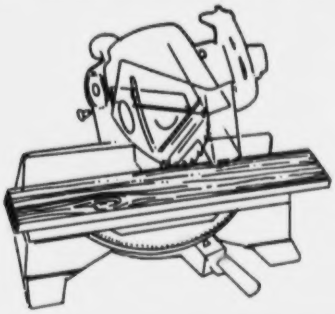
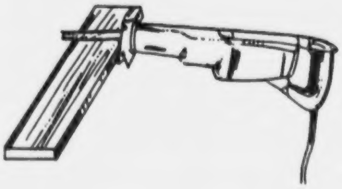


Figure 5.4



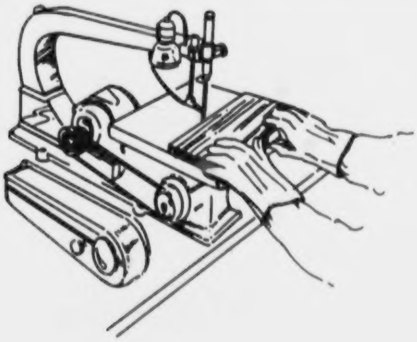
Using a Reciprocating Saw

A reciprocating saw is used many times when it is difficult to make the cut with another type of saw. It is similar to a saber saw except that the blade extends from the end of the saw rather than the bottom. (See Figure 5.4.) Its design is much like that of a chainsaw except that it uses a blade to cut rather than a chain. The reciprocating saw is used to make relief cuts in woodworking, as well as irregular cuts, inside curves, and pocket cuts. Several safety precautions should be observed when using a reciprocating saw. Disconnect the power source before changing the blade or making adjustments. Keep the cord away from the blade to prevent electrical shock. Never point the saw at another person. There are no guards on the blade and another person could easily be injured. Do not bind the blade or force it into the wood. Blades on a reciprocating saw will break easily if they are forced. Turn the saw off immediately after the cut is made. Be sure that the blade has come to a complete stop before laying the saw down. Be aware of objects behind or around the wood to be cut to avoid accidental cutting. If cutting a hole in a wall, be aware of where any electrical wiring is at to prevent cutting through the wire.

Using a Scroll Saw

A scroll saw, sometimes called a stationary jig saw, uses a thin blade that will allow for curves to be cut with precision. (See Figure 5.5.) It is used to make small radius cuts, inside cuts, and straight cuts. Several safety precautions should be considered when using a scroll saw. Always disconnect the saw from the power source when making adjustments. Keep belt guards in place at all times to prevent injury to yourself or others in the area. Check the blade for proper installation, with the teeth pointing downward. Excess tension in the blade can be eliminated by adjusting the guide assembly. Keep your fingers at least 4 inches from the blade at all times. Use the hold springs to prevent the wood from lifting off the table on the upward stroke of the blade.

Figure 5.5



Using a Pneumatic Nailer

Pneumatic (air-powered) nailers are becoming very popular in woodworking because of their convenience and speed. Pneumatic nailers are used to fasten wood together and to apply framing and finish work. Because of the pressure provided by the compressed air supply, pneumatic nailers can be very dangerous. Several safety procedures should be followed to prevent injury while using the tool. First of all, disconnect the nailer from the air source when loading or adjusting. NEVER point the nailer at another person. A pneumatic nailer is much like a loaded gun -- never assume that it is safe. These nailers are not toys and should not be treated as such. Accidentally hitting the trigger can result in severe damage to yourself or another person. Read the manufacturer's manual before using the nailer. Select the correct pressure setting based on the manufacturer's recommendation. You should keep your hands and feet away from the end of the nailer in case of an accidental discharge. Use only recommended fasteners for the style of nailer to prevent damage to the machine which could cause it to malfunction. Fasteners are released from the nailer with a great amount of force. Use the nailer only on materials that the fastener will not penetrate to prevent damage to the materials underneath the wood. The fastener should not go completely through the material.

If used properly, power tools can make woodworking much easier and less time-consuming. Since most power tools require the use of a blade or contain rotating parts, extreme caution must be taken to prevent injury to yourself or others in the shop area.

Credits

Groneman, Chris H. General Woodworking. Western Division: McGraw-Hill Book Company, 1982.

Wagner, Willis H. and Clois E. Kicklighter. Modern Woodworking. South Holland: The Goodheart-Willcox Co., Inc., 1986.

Demonstration Sheet 5.1: Using a Shaper

Objective: Upon completion of this demonstration, the student will be ready to begin the job sheet on using a shaper.

Tools and Equipment Needed:

1. Shaper
2. Cutter
3. Wrench
4. Push sticks
5. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - at least 10 inches long

Procedure:

1. Disconnect the shaper from the power source.

   CAUTION: To avoid accidental starting, unplug the shaper while making adjustments.

2. Clear all scrap lumber and sawdust from the table and floor.

3. Select the desired cutter.

4. Remove the table insert and raise the spindle with the wheel on the front.

5. Install the cutter and tighten the nut.

   CAUTION: Make sure that a lock washer is used under the nut to prevent the cutter from loosening during operation of the shaper.

6. Adjust the fence to provide the depth of cut desired and lock it in place. If the depth of cut is 1/2", the back fence should be set in 1/2" farther than the front fence to keep the board straight after it has gone through the cutter.

7. Turn the spindle and cutter by hand to make sure they clear the fence.

8. Connect the power source and turn the shaper on. Use a push stick to hold the board firmly against the fence and push the board through the cutter.

   CAUTION: Do not get your fingers closer than 6 inches to the cutter.

9. Get assistance from someone to support the end of long boards after they clear the cutter. This help should be secured prior to turning on the shaper.

10. Turn the shaper off. Flip the board over and shape the other side.

11. Turn the shaper off and clean the work area.

12. Assign JS 5.1 to be completed by students.

Demonstration Sheet 5.2: Using a Router

Objective: Upon completion of this demonstration, the student will be ready to begin the job sheet on using a router.

Tools and Equipment Needed:

1. Router
2. Bit
3. Wrench
4. Clamp
5. Guide
6. Straightedge
7. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Piece of lumber - size to be determined by the instructor

Procedure:

1. Disconnect the router from the power source.

   CAUTION: To avoid accidental starting, unplug the router while making adjustments or changing bits.

2. Clear a work area on the table.
3. Select a router bit for making straight cuts.
4. Insert the bit into the router and tighten the chuck.
5. Adjust the base of the router to provide the correct cutting depth.
6. Clamp the board to be routed to the table so that the clamp will not be in the way of the router or router base.
7. Set up the guide for the router to follow.
8. Align the router with the board to be cut. Plug the router in. Make sure the cord is out of the path of the router.
9. Face the board to be routed. Set the base of the router on the left edge of the board.

   CAUTION: The bit should not be in contact with the wood.

10. Hold the router firmly as you turn it on since it may kick as a result of the sudden power surge.

11. Hold the router against the edge of the guide to provide a straight edge.

12. The sound of the motor will indicate if the speed of cutting is satisfactory. Moving too fast will cause the motor to lug down. Moving too slowly will cause the wood to burn.

13. When the end of the board is reached, allow the bit to clear the end and turn off the router.

    CAUTION: To prevent injury, do not lift the router from the board until it has been turned off and the bit has stopped rotating.

14. Move the guide over to allow a second cut to be made. Align the bit to cut flush with the previous cut. Tighten the guide again to maintain proper alignment.

15. Complete the second cut, following the same procedures used for the first cut.

16. Turn off the router.

17. Assign JS 5.2 to be completed by students.

Demonstration Sheet 5.3: Using a Power Miter Box Saw

Objective: Upon completion of this demonstration, the student will be ready to begin the job sheet on using a power miter box saw.

Tools and Equipment Needed:

1. Power miter box saw
2. Pencil
3. Straightedge
4. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Disconnect the power source.

   CAUTION: To avoid accidental starting, unplug the power miter box saw while making adjustments or changing the blade.

2. Check the blade for breaks or cracks.

3. Mark a straight line on the board to be cut.

4. Align the mark with the blade by lowering the blade to the board.

   CAUTION: Be sure that the saw blade clears all guards or clamps.

5. Hold the board firmly against the fence to prevent movement during cutting.

   CAUTION: Short boards should be clamped to the table to prevent hands from getting too close to the blade.

6. Plug the saw in. Turn the saw on by the trigger control on the saw handle.

7. Apply downward pressure on the saw handle until the cut is complete.

8. Release the pressure on the trigger to stop the saw.

9. Once the blade has stopped, allow the saw to slowly return to its normal position.

   CAUTION: Make sure that the blade has come to a complete stop before reaching for the board.

10. Remove the board from the table and brush the sawdust from the table.

11. Assign JS 5.3 to be completed by students.

Demonstration Sheet 5.4: Using a Reciprocating Saw

Objective: Upon completion of this demonstration, the student will be ready to begin the job sheet on using a reciprocating saw.

Tools and Equipment Needed:

1. Reciprocating saw
2. Screwdriver
3. Blade
4. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Disconnect the power source.

   CAUTION: To avoid accidental starting, unplug the saw before making any adjustments.

2. Mark several straight and irregular lines on the board to be cut.

3. Clamp the board to be sawed to the table to prevent movement during the cutting operation.

4. Select the correct blade for the material to be cut.

5. Insert the blade into the end of the saw and tighten with a screwdriver.

6. Plug the saw in and align the blade to the line to be cut.

7. Turn the saw on by the trigger control on the saw handle.

8. Start the cut at the edge of the wood closest to the line. If the cut is to be made in the middle of a surface where you cannot cut in from the edge, the saw should be rested on the base near the blade and the blade gradually lowered into the wood to begin the cut.

9. Continue cutting until the cut is complete.

10. Release the pressure on the trigger to stop the saw.

11. Once the blade has stopped, lay the saw on the table.

    CAUTION: Make sure that the blade has come to a complete stop before reaching for the board.

12. Remove the board from the table and brush the sawdust from the table.
13. Unplug the saw and remove the blade from the saw to prevent it from being broken during storage.
14. Assign JS 5.3 to be completed by students.

Demonstration Sheet 5.5: Using a Scroll Saw

Objective: Upon completion of this demonstration, the student will be ready to begin the job sheet on using a scroll saw.

Tools and Equipment Needed:

1. Scroll saw
2. Wrench
3. Pencil
4. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Select piece of wood to be cut. The surface of the wood should be smooth to allow for precision cuts.
2. Use a pencil to draw the pattern that is to be cut.
3. Disconnect the scroll saw from the power source before making any adjustments.

   CAUTION: To avoid accidental starting, unplug the scroll saw when making adjustments.
4. Clear the table of scrap wood and sawdust to provide a smooth work area, free of obstructions.
5. Check the blade for proper installation. The teeth on the blade should be pointed downward.
6. Adjust the guide assembly to prevent excessive movement of the blade during the operation. Use a wrench to tighten the guide assembly.
7. Turn the saw a few rotations by hand to check for proper alignment of the guide assembly.
8. Using the wood to be cut, adjust the height of the guide assembly. The hold springs should rest on top of the wood to prevent it from lifting off of the table on the upward blade movement.
9. Remove the wood from the table and plug the saw in.
10. Turn the saw on and slowly move the wood into the blade. Follow the lines drawn earlier on the wood.

    CAUTION: Do not get fingers closer than 4 inches to the blade.

11. When the cut is complete, turn the saw off.

    CAUTION: Wait for the blade to stop before removing the scrap wood from the table.

12. Assign JS 5.5 to be completed by the students.

Job Sheet 5.1: Using a Shaper

Objective: Upon completion of this job sheet, the student will be able to use a shaper.

Tools and Equipment Needed:

1. Shaper
2. Cutter
3. Wrench
4. Push sticks
5. Safety goggles*

*CAUTION: All students performing this procedure must wear proper eye protection at all times. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - at least 10 inches long

Procedure:

1. Disconnect the shaper from the power source.

   CAUTION: To avoid accidental starting, unplug the shaper before making any adjustments.

2. Clear all scrap lumber and sawdust from the table and floor to provide a safe work area.
3. Select the desired cutter to be used to shape the board. Follow the instructor's recommendation.
4. Remove the table insert and raise the spindle with the wheel on the front.
5. Install the cutter and tighten the nut, as shown in Figure 5.1.

   CAUTION: Make sure that a lock washer is used under the nut to prevent the cutter from loosening during operation.

6. Adjust and lock the fence in place to provide the depth of cut desired. (See Figure 5.2.)
7. Lower the spindle by turning the wheel on the front of the shaper until the proper height for the cut is reached.
8. Turn the spindle and cutter by hand to make sure they clear the fence.

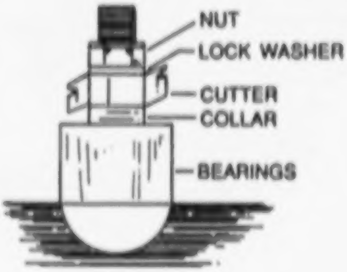


Figure 5.1

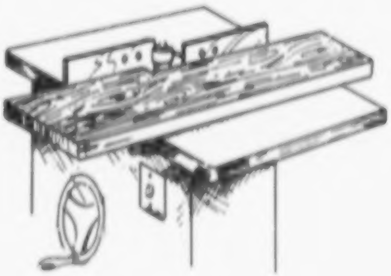


Figure 5.2

9. Plug the shaper back into the power source and run a scrap piece of lumber through to check the settings for accuracy. If the spindle height needs to be adjusted, repeat steps 1 through 8.

10. Use a push stick to hold the board firmly against the fence and push the board through the cutter.

    CAUTION: Do not get your fingers closer than 6 inches to the cutter.

11. Get assistance from a student to support the end of long boards after they clear the cutter to prevent the unshaped end from kicking up. This help should be secured before turning on the shaper.

12. Turn the shaper off.

13. Flip the board over, adjust the fence if necessary, and shape the other side.

14. Turn the shaper off and clean the work area.

15. Turn in your work to the instructor for grading.

Job Sheet 5.2: Using a Router

Objective: Upon completion of this job sheet, the student will be able to use a router.

Tools and Equipment Needed:

1. Router
2. Bit
3. Wrench
4. Clamp
5. Guide
6. Straightedge
7. Safety goggles*

*CAUTION: All students performing this procedure must wear proper eye protection at all times. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Piece of lumber - size to be determined by the instructor

Procedure:

1. Disconnect the router from the power source.

   CAUTION: To avoid accidental starting, unplug the router while making adjustments or changing bits.

2. Clear a work area on the table. Remove all scrap wood and sawdust so that a clean, flat surface can be used.

3. Select a router bit for making straight cuts. Follow the instructor's recommendation. Make sure the bit is sharp and clear of all pitch and gum.

4. Set the router on its top, insert the bit, and tighten the chuck.

5. Turn the base of the router to adjust the cutting depth to the desired level. Tighten the base once the depth has been set. Practice cuts should be made on a scrap piece of lumber until the correct depth is set.

6. Clamp the board to be routed to the table so that the clamp will not be in the way of the router or router base.

7. Set up the guide for the router to follow. Use the straightedge to make sure both ends are even so that a straight cut can be made.

8. Plug the router in and align it with the board to be cut. Make sure the cord is out of the path of the router, as illustrated in Figure 5.1.

9. Face the board to be routed. Set the base of the router on the left edge of the board.

   CAUTION: The bit should not be in contact with the wood when the power is turned on.

10. Hold the router firmly as you turn it on, since it may kick as a result of the sudden power surge.

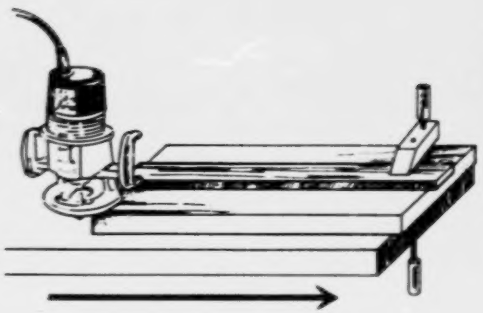


Figure 5.1

11. Since the router bit turns in a clockwise direction, the board should be routed from left to right, as shown in Figure 5.2.

12. Hold the router against the edge of the guide to provide a straight edge.

13. The sound of the motor will indicate if the speed of cutting is satisfactory. Moving too fast will cause the motor to lug down. Moving too slowly will cause the wood to burn.

14. When the end of the board is reached, allow the bit to clear the end, then turn off the router.

   CAUTION: To prevent injury, do not lift the router from the board until it has been turned off and the bit has stopped rotating.

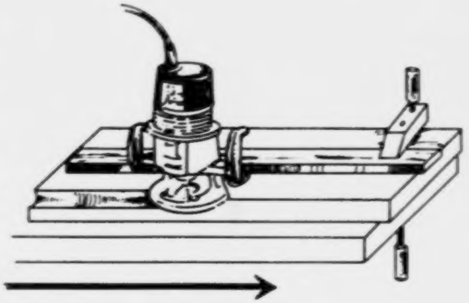


Figure 5.2

15. Move the guide over to allow a second cut to be made. Align the bit to cut flush with the previous cut. Tighten the guide again to maintain proper alignment.

16. Complete the second cut, following the same procedures used for the first cut.

17. Turn off the router and return it to the proper storage area.

18. Turn in your work to the instructor for grading.

Job Sheet 5.3: Using a Power Miter Box Saw

Objective: Upon completion of this job sheet, the student will be able to use a power miter box saw.

Tools and Equipment Needed:

1. Power miter box saw
2. Pencil
3. Straightedge
4. Safety goggles*

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Disconnect the power source.

   CAUTION: To avoid accidental starting, unplug the saw while making adjustments or changing the blade.

2. Check the blade for breaks or cracks.

3. Use the pencil and straightedge to mark a straight line on the board to be cut.

4. Plug the saw in and align the mark with the blade by lowering the blade to the board.

   CAUTION: Be sure that the saw blade clears all guards or clamps before operating the saw.

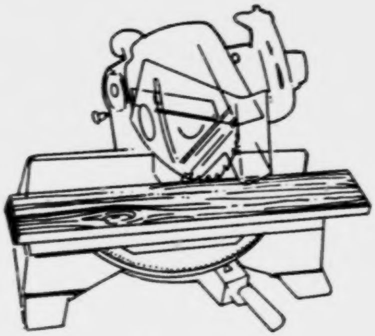


Figure 5.1

5. Hold the board firmly against the fence to prevent movement during cutting, as shown in Figure 5.1. Ask for assistance to support long boards to prevent them from kicking up into the saw when the cut is complete.

   CAUTION: Short boards should be clamped to the table to prevent hands from getting too close to the blade.

6. Turn the saw on by the trigger control on the saw handle.

7. The power miter box saw is spring-loaded. Apply downward pressure on the handle of the saw until the

blade comes into contact with the wood. Continue slowly applying pressure until the cut is complete.

8. Release the pressure on the trigger to stop the saw.

9. Once the blade has stopped, allow the saw to slowly return to its normal position.

   CAUTION: Make sure that the blade has come to a complete stop before reaching for the board.

10. Remove the board from the table and brush the sawdust from the table.

11. Turn in the cut to the instructor for grading.

Job Sheet 5.4: Using a Reciprocating Saw

Objective: Upon completion of this job sheet, the student will be able to use a reciprocating saw.

Tools and Equipment Needed:

1. Reciprocating saw
2. Screwdriver
3. Blade
4. Safety goggles*

*CAUTION: All students observing this procedure must wear proper eye protection at all times. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Disconnect the power source.

   CAUTION: To avoid accidental starting, unplug the saw while making adjustments or changing the blade.

2. On the board to be cut, mark several straight and irregular lines as assigned by the instructor.

3. Clamp the board to be sawed to the table to prevent movement during the cutting operation.

4. Select the correct blade for the material to be cut. Long blades are needed for deep cuts. Fine-toothed blades are used for smooth cuts.

5. Insert the blade into the end of the saw and tighten with a screwdriver.

6. Plug the saw in and move the blade to the line to be cut.

7. Turn the saw on by the trigger control on the saw handle.

8. Start the cut at the edge of the wood closest to the line. If the cut is to be made in the middle of a surface where you cannot cut in from the edge, the saw should be rested on the base near the blade and the blade gradually lowered into the wood to begin the cut.

9. Continue cutting until the cut is complete, making sure that nothing is on the other side of the cut that will be damaged by the blade. (See Figure 5.1.)

10. Release the pressure on the trigger to stop the saw.

11. Once the blade has stopped, lay the saw on the table. Unplug the saw.

    CAUTION: Make sure that the blade has come to a complete stop before reaching for the board.

12. Remove the board from the table and brush the sawdust from the table.

13. To prevent the blade from being broken, remove it from the saw before returning the saw to the storage area.

14. Turn in your work to the instructor for grading.

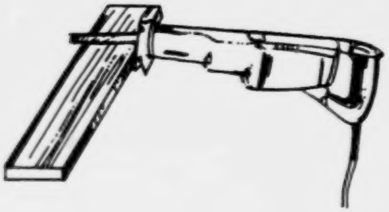


Figure 5.1

Job Sheet 5.5: Using a Scroll Saw

Objective: Upon completion of this job sheet, the student will be able to use a scroll saw.

Tools and Equipment Needed:

1. Scroll saw
2. Wrench
3. Pencil
4. Safety goggles*

*CAUTION: All students performing this procedure must wear proper eye protection at all times. Safety precautions must be observed at all times while in the shop area.

Materials Needed:

1. Scrap lumber - size to be determined by the instructor

Procedure:

1. Select piece of wood to be cut. The surface of the wood should be smooth to allow for precision cuts to be made. If the surface is not smooth, the wood may need to be sanded.

2. Use a pencil to draw the pattern that is to be cut. Draw both straight and curved lines.

3. Disconnect the scroll saw from the power source before making any adjustments.

   CAUTION: To avoid accidental starting, unplug the saw when making adjustments or changing the blade.

4. Clear the table of scrap wood and sawdust to provide a smooth work area.

5. Check the blade for proper installation. The teeth on the blade should be pointed downward.

6. Adjust the guide assembly to prevent excessive movement of the blade during the operation. Use a wrench to tighten the guide assembly.

7. Turn the saw a few rotations by hand to check for proper alignment of the guide assembly.

8. Using the wood to be cut, adjust the height of the guide assembly. The hold springs should rest on top of the wood to prevent it from lifting off of the table on the upward blade movement.

9. Remove the wood from the table and plug the saw in.

10. Turn the saw on and slowly move the wood into the blade. Follow the lines drawn earlier on the wood. (See Figure 5.1.)

    CAUTION: Do not put fingers closer than 4 inches to the blade.

11. When the cut is complete, turn the saw off.

    CAUTION: Wait for the blade to stop before removing the scrap wood from the table.

12. Clean the work area of scrap wood and sawdust.

13. Turn in your work to the instructor for grading.

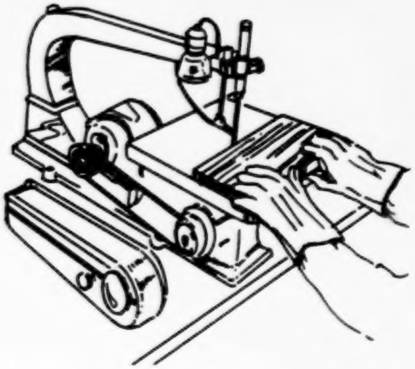


Figure 5.1

Lesson 6: Preservatives

Objective: The student will be able to select the proper preservative for wood.

Study Questions

1. **Why should wood be preserved?**
2. **What are the different types of preservatives and sealers?**
3. **What determines the service life of a wood?**
4. **What wood products require treatment?**
5. **Where can treated lumber be purchased?**
6. **What safety precautions should be observed when using sealers?**

Reference

1. Handout
    a) HO 6.1: Treating Lumber

Lesson 6: Preservatives

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Wood that has not been preserved properly for outside use will decay very quickly. Show students several different pieces of wood, some that have been preserved properly and some that have not. Discuss the differences and how these differences affect the life of the wood.

C. Assignment

D. Supervised study

E. Discussion

1. Many projects made in the agricultural education shop are designed for outside use. When a wood is exposed to the weather, treatment will make the project last longer. Discuss reasons for preserving wood.

Why should wood be preserved?

a) Protect wood from moisture
b) Protect wood against insects and organisms
c) Increase the durability and quality of the project

2. Many types of wood preservatives and sealers are available for treating wood. Discuss the difference between preservatives and sealers.

What are the different types of preservatives and sealers?

a) Preservatives
    1) CCA - restricted use
    2) Pentachlorophenol - restricted use
    3) Creosote - restricted use
    4) Copper naphthenate - not restricted
b) Sealers
    a) Shellac
    b) Lacquer-base
    c) Oil-base
    d) Latex-base

3. Woods differ in their ability to resist decay or termite destruction. Discuss the types of wood and their need for treatment.

What determines the service life of wood?

a) Amount of heartwood and sapwood
b) Natural resistance
    1) High - red cedar, black locust, osage orange
    2) Intermediate - cypress, white oak, shortleaf pine, mulberry
    3) Low - ash, cottonwood, hickory, maple, red oak, sycamore

4. Woods that are used near the ground or are exposed to moisture need to be treated to increase their durability. Ask the class to list situations when wood will need to be treated.

What wood products require treatment?

a) Posts
b) Poles
c) Lumber used outside or near the ground
d) Exterior plywood
e) Stair stringers

5. There are two main sources of treated lumber in Missouri. Discuss these sources with students and how to determine which source to use.

Where can treated lumber be purchased?

a) Manufacturers
b) Lumber yards

6. Since sealers are chemical substances, safety should always be a consideration when applying sealers. Discuss the safety precautions that should be observed when using sealers with the class.

What safety precautions should be observed when using sealers?

a) Use in a well-ventilated area.
b) Read the directions on the can.
c) Wear a respirator.
e) Do not eat, drink, or smoke while applying sealers.
f) Wash hands after application.
g) Wear rubber gloves to avoid contact with the skin.
h) Keep away from flammable materials.
i) Dispose of used rags.
j) Do not store in direct sunlight.
k) Clean up spills immediately.

F. Other activities

1. Display and label a sample board using each of the wood preservatives available.

2. Visit the local lumber yard and look at all the possible preservatives available for purchase.

3. Tour a lumber treatment operation to observe the process of lumber preserving.

G. Conclusion

A properly treated piece of wood will last much longer than one that is not treated. Wood treated with a preservative will withstand the weather, insects, and decay, which will increase the durability and quality of the project.

H. Competency

Select preservatives.

I. Answers to Evaluation

1. c
2. d
3. b
4. c
5. b
6. d
7. d
8. b
9. c
10. a

UNIT III - WOODWORKING Name__________________

Lesson 6: Preservatives Date__________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is a reason to preserve wood?

   a. To improve the appearance of the wood
   b. To decrease the quality of the wood
   c. To increase the durability of the wood
   d. To increase the moisture content of the wood
   e. To attract insects to the wood

2. Treatment can improve the service life of a wood by as much as _________.

   a. Six months
   b. One to two years
   c. Five to ten years
   d. Twenty to thirty years
   e. One hundred to two hundred years

3. Which of the following preservatives does not have a restricted use?

   a. Creosote
   b. Copper naphthenate
   c. CCA
   d. Shellac
   e. Pentachlorophenol

4. Which of the following preservatives should not be painted over?

   a. CCA
   b. Copper naphthenate
   c. Creosote
   d. Shellac
   e. Pentachlorophenol

5. Which of the following preservatives will give the wood a deep, brown, rustic appearance?

   a. Copper sulfate
   b. Pentachlorophenol
   c. Creosote
   d. CCA
   e. Copper naphthenate

6. The most widely used preservative on the market today is ______.

   a. Copper sulfate
   b. Pentachlorophenol
   c. Creosote
   d. CCA
   e. Copper naphthenate

7. Which preservative will turn the surface of the wood a green color?

   a. Iron oxide
   b. Pentachlorophenol
   c. CCA
   d. Copper naphthenate
   e. Creosote

8. Which of the following is not a type of sealer for wood?

   a. Shellac
   b. Water-based sealer
   c. Latex-based sealer
   d. Oil-based sealer
   e. Lacquer-based sealer

9. Which organization regulates the use of preservatives?

   a. Department of Natural Resources
   b. Department of the Interior
   c. Environmental Protection Agency
   d. Food and Drug Administration
   e. Missouri Conservation and Forestry Commission

10. Which of the following trees is highly resistant to decay and insects?

   a. Red cedar
   b. Ash
   c. Cypress
   d. White oak
   e. Sycamore

Why Wood Is Preserved

Many projects made in the agricultural education shop are designed to be used outside. When wood is exposed to the weather, treatment will make the project last longer by protecting it from fungus, organisms, and insects which cause decay. To prevent decay, the wood should be treated if it is in contact with the soil or subject to a continuous source of moisture. Any wood in contact with the soil will absorb water and eventually decay if it is not treated. Preservatives and sealers are used to protect wood against decay from wood-destroying organisms and insects, such as termites. When wood is treated, the durability and quality of the project is greatly increased. The life of wood can be increased by as much as twenty to thirty years, if properly treated.

Preserving Wood

Preservatives - Many types of wood preservatives are available for treating wood. Most preservatives used for treating wood are classified as "restricted use" by the Environmental Protection Agency (EPA) and can be potentially hazardous to users. Wood that has been treated with restricted preservatives may be purchased by anyone, but the preservative itself may be sold to and used only by certified applicators or persons under their direct supervision. Four types of preservatives are commonly used to preserve wood.

1. The first type is copper chrome arsenate (CCA). CCA is the most widely used preservative on the market today. This preservative is a water solution that does not give off an odor and, therefore, is recommended for use in confined spaces as well as for exterior use. CCA lumber is kiln dried and can be painted or stained.

2. Pentachlorophenol (penta) is the second type of preservative used to treat wood. Penta has a light oil base and gives off an unpleasant odor. Penta-treated wood is usually not kiln dried and has a fifteen to twenty percent moisture content. If properly nailed or glued during construction, warping should not be a problem. Penta-treated wood can be painted, but special procedures must be used to provide satisfactory results. The treatment itself gives the wood a deep brown color that provides a "rustic" look to the project. Penta-treated wood is safe to use in most outdoor applications, but it should not be used when the wood will be in contact with plants or animals.

3. The third type of preservative is creosote. Creosote is used mainly to treat railroad ties and poles. Creosote has a strong, undesirable odor and an oily, unpaintable surface. The lumber has a tendency to bleed and should not be used in a home environment because of the toxic fumes. The estimated life of lumber treated with creosote is in excess of fifty years.

4. Copper naphthenate is the fourth type of preservative to be discussed. Copper naphthenate is not a restricted-use preservative, thus adding to its popularity since it is not harmful to the user. It is an oil-soluble solution which can be brushed or sprayed on wood, or the wood may be dipped in it. Copper naphthenate turns the wood a green color that is difficult to cover with paint. It has a strong odor and tends to be more expensive than the other preservatives.

When purchasing treated lumber, be cautious of wood that has been dipped in oil or tar solutions. Oil and tar are not wood preservatives and will not significantly extend the life of the wood. Their appearance makes them look as if they have been treated with pentachlorophenol, but their ability to resist decay and insect damage is minimal. The Missouri

Treated Timber Law requires all dipped products to be labeled with a tag that warns the purchaser that the wood is not preserved.

Sealers are used to seal out moisture and dirt from the wood. They are not only used as a sealer, but as a preservative in many applications. Their use is not restricted by the EPA and they can be purchased at most hardware stores and lumber yards. Sealers come in different varieties of bases. Shellac is one of the most widely used sealers on the market. Lacquer-based, oil-based, and latex-based sealers are also available. Most sealers dry quickly and are sanded to provide a foundation for a surface coat of varnish.

Service Life of Wood

Woods differ in their ability to resist decay or termite destruction. The heartwood of some species has a relatively high degree of natural resistance. These woods might be used in some applications without any treatment. The sapwood of all species is highly susceptible to decay and insect attack under the appropriate moisture conditions. Red cedar, black locust, and osage orange all possess a high resistance (approximately fifteen years) to decay and insects. Cypress, white oak, shortleaf pine, and mulberry all have intermediate resistance (seven to fifteen years.) Ash, cottonwood, hickory, maple, red oak, and sycamore have a low natural resistance and will last approximately two to seven years without treatment. It is important to recognize that untreated woods with a high degree of natural resistance to deterioration will not have a life expectancy of more than fifteen years without treatment. The type of tree will determine the ability to be preserved. Some woods are more easily treated with preservatives than others. Pine can be treated rather easily, whereas white oak is very difficult to treat because of the impenetrable heartwood. The more heartwood that a post contains, the longer the wood will last. Lumber cut from the heartwood of the tree, rather than the sapwood, will last longer than lumber cut from the sapwood.

Treated Wood Products

If exposed to weather, posts, poles, plywood, and stair stringers are all applications where wood preservatives are needed to improve the durability of the wood. These types of wood are subject to both moisture and insects and will require preservation if they are to last. As a rule of thumb, all wood within eighteen inches of the ground should be treated to protect it from termites. If cuts or holes are made during construction of the project, a preservative or sealer should be brushed on the cut to prevent moisture and insects from entering in the untreated area. If the board has been machined, the machined surface should be pointing upward to control moisture entry into the wood.

Purchasing Treated Lumber

Earlier we discussed that most wood preservatives are "restricted use"; therefore, a licensed applicator must purchase and apply them to wood. For this reason, wood that has been chemically preserved must be purchased from basically two sources. The first source of treated lumber is from treatment plants. Manufacturers (treating plants) have a wholesale price schedule for quantity buyers and retailers. They also sell smaller quantities to individual buyers at retail prices. The second source of treated lumber is from a lumber yard. Not all lumber yards stock treated wood, but they can get it for you if it is not in stock. The source you use to purchase treated lumber will depend on your location, amount of treated lumber needed, and the cost of the lumber.

Safety Precautions for Sealers

Since sealers are chemical substances, safety should always be a consideration when applying them. The following precautions are important to consider when applying sealers. Always read and follow label directions. The label will indicate the proper methods of application and safety precautions. The area should be well-ventilated to prevent build-up of the fumes. Wear a respirator when applying sealer to avoid inhaling the fumes. Keep the sealer away from flammable materials while applying it. Avoid contact of the sealer with your skin. Wear rubber gloves while applying to prevent skin irritation. Wash your hands thoroughly with soap and water after application to remove all sealer from them. Do not eat, drink, or smoke while applying the sealer. Clean up spills immediately. Dispose of used rags in a sealed metal container. Do not store the sealer in direct sunlight or near flammable materials.

Credits

Pastoret, James and Troy Klein. "Treated Wood Products Available in Missouri." Agricultural Guide 5505. University of Missouri-Columbia Extension Division.

Pastoret, James. "Use of Treated Wood." Agricultural Guide 5501. University of Missouri-Columbia Extension Division.

UNIT IV - METALS

GETTING READY FOR THIS UNIT

Some of the information presented in this unit is a continuation of the competencies taught in the Agricultural Science I and II core curriculums. It is noted in the lesson when information needed to master a competency has been addressed in another curriculum. Some of the job sheets included in this unit will require previous instruction in oxy-acetylene and using a drill press. This should be kept in mind when planning the teaching calendar. Due to the large number of references used to develop this unit, a student handout has been developed for each lesson.

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OBJECTIVES

1. The student will be able correctly select metals based on design and strength characteristics.
2. The student will be able to recognize the common metal shapes and explain how each piece is measured.
3. The student will be able to identify and remove stress raisers that cause weld failure.
4. The student will be able to identify the types of metal fasteners used in project construction.
5. The student will be able to correctly identify the hardness grade of a bolt.
6. The student will be able to control heat distortion in metals.
7. The student will be able to correctly use locks and fasteners in metal projects.
8. The student will be able to identify the methods of bending metal using heat.
9. The student will be able to hand and machine thread metal pieces.
10. The student will be able to describe the methods of heat treatment and their effects on metal.

COMPETENCIES

1. Select metals by design and strength.
2. Explain how construction metal is dimensioned.
3. Remove stress raisers.
4. Identify common metal fasteners.
5. Identify the hardness grade of a bolt.
6. Control heat distortion of metals.
7. Assemble work using proper locks and fasteners.
8. Use heat to shape metals.
9. Use a tap and die set to do threading.
10. List the steps used in tempering, annealing, hardening, wrinkle bending, normalizing, and welding to control crystallization.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Provide samples of several different types of metal. Ask students to identify the types of metals and describe situations in which they would be used. Provide situations and ask

students which types of metals would be appropriate to use. Also have students identify metals that would not work in each situation.

2. Secure a piece of mild steel in a vise and bend it with a hammer. Then secure a piece of cast iron in the same vise and try to bend it with a hammer. Ask students to describe why one piece breaks, while the other bends. Discuss the importance of knowing the characteristics of metal when constructing or repairing machinery or equipment.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

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2. Teacher References

    a) "Agricultural Mechanics Unit", Agricultural Science I Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

    b) Allen, Dell K. Metallurgy Theory and Practice. Chicago: American Technical Society, 1969.

    c) Brandt, Daniel A. Metallurgy Fundamentals. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

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    e) Jefferson, T. B. and Gorham Woods. Metals and How to Weld Them. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 1983.

    f) Ludwig, Oswald A.; Willard J. McCarthy; Victor E. Repp. Metalwork Technology and Practice. Bloomington: McKnight Publishing Company, 1975.

    g) Morford, V. J.; Thomas A. Hoerner; Willard R. Anderson. Metals and Welding. St. Paul: Hobar Publications, 1970.

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    i) Walker, John R. Modern Metalworking. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

Agricultural Construction
Unit IV - Metals
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N	**Metals**
				1. Select metals by design and strength
				2. Explain how construction metal is dimensioned
				3. Remove stress risers
				4. Identify common metal fasteners
				5. Identify the hardness grade of a bolt
				6. Control heat distortion of metals
				7. Assemble work using proper locks and fasteners
				8. Use heat to shape metals
				9. Use tap and die set to do threading
				10. List steps used in tempering, annealing, hardening, wrinkle bending, normalizing and welding to control crystallization
				Other (specify)
				______________________________
				______________________________

Agricultural Construction
Unit IV - Metals

Class/Section: ____________________

Students:	Select metals by design and strength	Explain how construction metal is dimensioned	Remove stress risers	Identify common metal fasteners	Identify the hardness grade of a bolt	Control heat distortion of metals	Assemble work using proper locks and fasteners	Use heat to shape metals	Use tap and die set to do threading	List steps used in tempering, annealing, hardening, wrinkle bending, normalizing and welding to control crystallization			

UNIT IV - METALS

Lesson 1: Selecting Metals

Objective: The student will be able to correctly select metals based on design and strength characteristics.

Study Questions

1. **Why is it important to accurately select metals?**
2. **How do the mechanical properties of common metals compare?**
3. **How are metals classified?**

Reference

1. Handout
    a) HO 1.1: Selecting Metals

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Lesson 1: **Selecting Metals**

TEACHING PROCEDURES

A. Review

Introduce the unit.

B. Motivation

Show three different pieces of metal to the students. Discuss the composition of each metal. Then ask the students to discuss what makes the pieces of metal, which may look the same, different. Explain the chemical background of each metal (e.g., gold, tungsten, zinc).

C. Assignment

D. Supervised study

E. Discussion

1. When planning a project for agricultural construction, it is important to consider the type of metal to be used. Discuss the points below with the class. Provide a few construction situations for the class and ask them to choose the type of metal they would use for the construction project.

   Why is it important to accurately select metals?

   a) Safety of the project
   b) Economics - cost, avoid waste, availability of the metal
   c) Increase the life of the project
   d) Compatibility with other metals used
   e) Type of welding processes available

2. The following mechanical properties will be compared for low-, medium-, and high-carbon steels, cast iron, aluminum, and wrought iron. Mechanical properties are ranked in order of best to worst for the metals.

   How do the mechanical properties of common metals compare?

   a) Tensile strength - resistance of metal to be pulled apart
      1) High-carbon steel - 140,000 psi
      2) Medium-carbon steel - 110,000 psi
      3) Low-carbon steel - 70,000 psi
      4) Aluminum - 40,000 psi
      5) Wrought iron - 40,000 psi
      6) Cast iron - 35,000 psi
   b) Compression strength - resistance of a metal to crushing
      1) High-carbon steel - 140,000 psi
      2) Medium-carbon steel - 110,000 psi
      3) Cast iron - 110,000 psi

        4) Low-carbon steel - 70,000 psi
        5) Wrought iron - 40,000 psi
        6) Aluminum - 40,000 psi
    c) Bendability - the resistance of a metal to bending under stress without breaking
        1) Steel - good
        2) Wrought iron - good
        3) Aluminum - fair to good
        4) Cast iron - poor
    d) Weldability - the ease in which a metal may be welded, shaped, and worked
        1) Low-carbon steel - easily welded, easily formed, ductile
        2) Wrought iron - easily welded
        3) Medium-carbon steel - not easily welded (especially at the higher levels of carbon content), strong, hard
        4) High-carbon steel - special welding techniques usually required, easily heat treated
        5) Cast iron - special heat treatment and filler metal required, brittle
        6) Aluminum - special welding procedures required
    e) Hardness - resistance to being dented or deformed by another object
        1) Steel - good
        2) Wrought iron - good
        3) Cast iron - fair to good
        4) Aluminum - poor
    f) Carbon content
        1) Low-carbon steel - .05 - .35%
        2) Wrought iron - .06 - .08%
        3) Medium-carbon steel - .35 - .50%
        4) High-carbon steel - .50 - 1.0%
        5) Cast iron 2.0 - 6.0%
        6) Aluminum - no carbon content

3. Not all metals of the same type have the same characteristics. Discuss with the class the method in which metals are classified.

    How are metals classified?

    a) A number is assigned by the SAE (Society of Automotive Engineers) to describe the chemical composition of the metal.
    b) Usually a four digit number is used to describe the characteristics of carbon and alloy steels.
        1) First digit - type of steel
        2) Second digit - not always, but generally amount of alloy
        3) Last two or three digits - carbon content in hundredths of a percent
    c) Carbon steel is a 10xx.
    d) Prefix letters are used to describe the process used to form the metal.
    e) Suffix letters are used to designate quality descriptions.

F. Other activities

1. Have various types of metals available for students to select which type is proper for a given project.

2. Construct a bulletin board on metal design and strength.

G. Conclusion

Because there are so many types of metal, all with a different design and strength, it is essential that a working knowledge for selecting proper metals be maintained. The selection of metals is the first important step in constructing any project. The correct selection will greatly enhance the looks, lasting ability, and enjoyment of a project.

H. Competency

Select metals by design and strength.

I. Answers to Evaluation

1. c
2. e
3. a
4. b
5. b
6. c
7. c
8. b
9. a
10. Three of the following: economics, safety, increase the life of the project, compatibility with other metals used, type of welding process used

Name ____________________

Lesson 1: Selecting Metals

Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The resistance of a metal to crushing is referred to as _________.

   a. Ductility
   b. Tensile strength
   c. Compression strength
   d. Torsional strength
   e. Weldability

2. The resistance of a metal to being pulled apart is referred to as _________.

   a. Compression strength
   b. Ductility
   c. Weldability
   d. Bendability
   e. Tensile strength

3. Which of the following metals has the highest carbon content?

   a. Cast iron
   b. Low-carbon steel
   c. High-carbon steel
   d. Wrought iron
   e. Aluminum

4. Which of the following metals has the lowest carbon content?

   a. Wrought iron
   b. Aluminum
   c. Cast iron
   d. Low-carbon steel
   e. Medium-carbon steel

5. The Brinell Test is used to determine the ________ of a metal.

   a. Ductility
   b. Hardness
   c. Weldability
   d. Bendability
   e. Carbon content

6. Which of the following metals is the hardest to bend without breaking?

   a. Wrought iron
   b. Low-carbon steel
   c. Cast iron
   d. Aluminum
   e. High-carbon steel

7. The first digit in a metal classification number indicates ________.

   a. Amount of alloy used
   b. Year produced
   c. Type of metal
   d. Carbon content
   e. Weldability

8. The last two or three digits in a metal classification number are used to indicate ________.

   a. Amount of alloy
   b. Carbon content
   c. Bendability
   d. Hardness test results
   e. Type of metal

9. Prefixes are used on metal classification systems to describe the ________.

   a. Process used to form the metal
   b. Hardness test results
   c. Weldability
   d. Quality description of the metal
   e. Carbon content

Complete the following short answer question.

10. What are three reasons why it is important to accurately select metals?

   a.

   b.

   c.

The type of metal to be used is an important consideration when planning a project for agricultural construction if the project is to serve the purpose for which it was designed. Several factors should be considered when selecting the type of metal that will be used.

Economics - One of the most important factors involved is economics. You should choose the metal that will be the least expensive, but still provide you with the characteristics needed for the project. By carefully planning the project, you can avoid wasting metal by ordering lengths that will most closely match the lengths needed for the project.

Safety - The proper type of metal should be selected that will give the project the strength needed for safe operation and use of the project. Not all metals have the same strength and cannot always be substituted for one another.

Life of the Project - The metal you select should be strong enough to last as long as the project will be needed. Some metals will rust and breakdown faster than others, depending on the conditions in which the project is used.

Compatibility with Other Metals - You should use metals that will work well with the other types of metal used in the project. Some metals will deteriorate when they come in contact with other types of metals. Also, changing types of metals for parts of the project may cause weakening in the project that could result in failure of the project or cause a hazardous operating situation.

Type of Welding Process - The type of metal you select may depend on the type of welder you will use. You should not plan a project to be made of aluminum if you do not have the proper equipment or skills needed to weld aluminum.

Properties of Metal

There are many properties of metal that should be taken into consideration when selecting the type of metal to be used in the construction of a project.

Tensile strength - Tensile strength is the resistance of a metal to be pulled apart and is rated in pounds per square inch (psi). It is probably the most important property to consider when selecting a metal. When large amounts of tension are placed on a metal, it will cause the particles that make up the metal to be pulled away from each other. If the project to be constructed will be subject to a large amount of tension, a metal with a high tensile strength should be used. The different types of metal will have different resistances to these pulling forces. The tensile strengths of the different metals are listed below.

Type of Metal	Tensile Strength (psi)
High-carbon steel	140,000 psi
Medium-carbon steel	110,000 psi
Low-carbon steel	70,000 psi
Aluminum	40,000 psi
Wrought iron	40,000 psi

Compression Strength - Compression strength is the resistance of the metal to crushing. Compressive strength is also rated in pounds per square inch. A metal will usually have a compressive strength similar to its tensile strength. If the project being constructed will be required to carry a heavy load, a high compressive strength will be required. The compressive strengths of several metals are listed below.

Type of Metal	Compressive Strength (psi)
High-carbon steel	140,000 psi
Medium-carbon steel	110,000 psi
Cast iron	110,000 psi
Low-carbon steel	70,000 psi
Wrought iron	40,000 psi
Aluminum	40,000 psi

Bendability - Bendability is the resistance of a metal to bending under stress without breaking. Some metals are more bendable than others. The bendability rating of several metals is listed below.

Type of Metal	Bendability Rating
Steel	Good
Wrought iron	Good
Aluminum	Fair to good
Cast iron	Poor

Weldability - Weldability is the ease in which a metal may be welded, shaped, and worked. Metals will vary greatly in the degree of weldability. You should consider the type of welding process to be used when selecting the metal for the project. Several metals are rated below for their degree of weldability.

Type of Metal	Weldability Characteristics
Low-carbon steel	Easily formed and welded, ductile
Wrought iron	Easily formed and welded
Medium-carbon steel	Not easily welded, especially at the higher levels of carbon content, strong, hard
High-carbon steel	Special welding techniques usually required, easily heat treated
Cast iron	Special heat treatment and filler metal required, brittle
Aluminum	Special welding procedures required

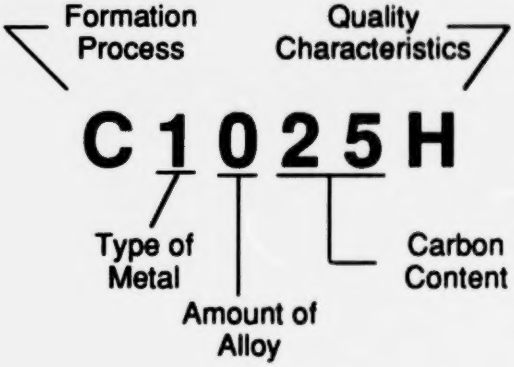
Hardness - Hardness is the resistance to being dented or deformed by another object. Many types of processes are used. One of the most common is the Brinell Hardness Test. Hardness is tested by using an object that is harder than the metal (often a diamond) to indent the metal. Once the dent is made, the diameter of the dent is measured and a hardness value is assigned. Steel has the highest hardness rating of the metals discussed, followed by cast iron, wrought iron, and aluminum.

Carbon Content - Metals will vary with the amount of carbon that is present in their structure. As a general rule, the more carbon that is present, the harder the metal is to weld. The carbon content of several metals is listed below.

Type of Metal	Carbon Content (%)
Low-carbon steel	.05 - .35
Wrought iron	.06 - .08
Medium-carbon steel	.35 - .50
High-carbon steel	.50 - 1.7
Cast iron	1.7 - 6.0
Aluminum	Contains no carbon

Metal Classification

When metal is processed it is assigned a number by the SAE (Society of Automotive Engineers) which describes the chemical composition of the metal. If the project you are constructing must meet certain rigid standards, the SAE classification number will be very important. Usually a four digit number is used to describe the characteristics of carbon and alloy steels. The first digit describes the type of metal. The second digit usually refers to the amount of alloy metal included in the metal. The last two or three digits denote the carbon content of the metal in hundredths of a percent. Prefixes and suffixes are also used in the SAE classification system for metals. Prefixes will describe the process that was used to form the metal, while the suffixes will describe the quality of the metal.



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UNIT IV - METALS

Lesson 2: Construction Metal Shapes and Sizes

Objective: The student will be able to recognize the common metal shapes and explain how each piece is measured.

Study Questions

1. **Why is it important to know the shapes and sizes of common construction metal?**
2. **How is the thickness of construction metal measured?**
3. **What is the correct name for each shape of metal?**
4. **How are size specifications written for each shape of metal?**
5. **What are the standard lengths for common metal shapes?**
6. **How can the weight per foot of flat steel be estimated?**

Reference

1. Handout
    a) HO 2.1: Construction Metal Shapes and Sizes

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UNIT IV - METALS

Lesson 2: Construction Metal Shapes and Sizes

TEACHING PROCEDURES

A. Review

Review the previous lesson on selecting metals.

B. Motivation

Display different metal shapes (pipe, angle, strip, flat, plate, S beam, wide flange beam, channel, reinforcing bar, round bar, hexagon bar, and square bar) on a table in front of room. Ask how many students can identify all of the shapes. Explain that after this lesson, the students will be able to name each piece, tell how each is sized, list standard sizes for each shape, and estimate the weight per foot for most shapes.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the importance of knowing the shapes and sizes of common construction metal.

   Why is it important to know the shapes and sizes of common construction metal?

   a) Communicate with other workers.
   b) Complete a bill of materials accurately.
   c) Order materials in a more efficient manner.
   d) Estimate construction costs accurately.

2. Metals are referred to by their specific gauge. Explain the importance of understanding the differences between gauges when ordering metal for project construction.

   How is the thickness of construction metal measured?

   a) A gauge number is used to represent the thickness of metal less than 3/16 inch thick. Gauge numbers are inversely related to metal thickness; larger gauge numbers represent thinner pieces of metal while smaller gauge numbers represent thicker pieces of metal.
   b) Ferrous metals are measured with the Manufacturer's Standard Gauge.
   c) American Standard Wire Gauge is used to measure the thickness of nonferrous metals.
   d) The difference between these two gauges is that the American Standard gauge is smaller than the Manufacturer's Standard Gauge. Therefore, any particular gauge of nonferrous metal will be thinner than the same gauge of ferrous metal. For example, 11 gauge aluminum is .090 inch thick while 11 gauge steel is .1196 inch thick.

3. Hold up each shape of metal one at a time. Ask the students to name each shape as you hold it up. Use HO 2.2 to illustrate the various shapes of metal used in agricultural construction.

   What is the correct name for each shape of metal?

   a) Sheet
   b) Plate
   c) Strips
   d) Flats
   e) Angle
   f) S beams
   g) Wide flange beams
   h) Channel
   i) Bars
   j) Reinforcing bars
   k) Tubing
   l) Pipe

4. When ordering metal, it is important to understand how the size of metals are specified so that an error is not made.

   How are size specifications written for each shape of metal?

   a) Sheet, plate, strip, flats, and square bars are specified as follows: thickness x width x length.
   b) Angles are specified by giving the width of the longest leg x width of the shortest leg x thickness x length.
   c) S beams, wide flange beams, and channels are specified by stating the appropriate symbol and depth x weight per foot x length.
   d) Round and hexagon bars are specified by stating the diameter x length.
   e) Reinforcing bars are specified by stating the diameter (as a whole number, over 8) x length. For example, a #4 x 20 foot reinforcing bar is 4/8 or 1/2 inch in diameter and 20 feet long.
   f) Square structural tubing is specified by stating the outside dimensions x wall thickness (gauge) x length. For example, 3" x 3" x .065 x 20'. Rectangular structural tubing is specified by stating the long outside dimension x short outside dimension x wall thickness (gauge) x length. For example, 4" x 2" x .065 x 20'.
   g) Pipes are specified by stating the nominal I.D., the schedule number, and the length.
   h) To avoid mistakes, always use the decimal equivalent with the gauge number when ordering.

5. Not all metals are available in the same lengths. When planning a project, consider the lengths that metals must be ordered since it will affect the cost of the project. Use local suppliers' catalogs to see the available lengths of metal.

   What are the standard lengths for common metal shapes?

   a) Flat stock - The most common length for flat stock (excluding sheets and plates) is 20 feet.
   b) Sheets and plates are available in standard lengths of 96, 120, 144, and 240 inches.

c) Angles, channels, S beams, and wide flange beams are most commonly available in 20 foot lengths; 40 and 60 foot lengths are also available.
d) Round, hexagon, and square bars are available in standard 20 foot lengths.
e) Reinforcing bar is available in 20, 30, and 40 foot lengths.
f) Structural tubing is generally available in lengths of 17 to 24 feet.
g) Pipe is available in standard 21 foot lengths.

6. Hold up a piece of flat stock and ask how much it weighs per foot. Emphasize that the formula is only an estimate. Using the formula, calculate the weight of a piece of flat steel. Then compare the calculated weight to the weight listed in a institutional catalog. The instructor could have students estimate the weight by using the catalog instead of calculating the weight.

How can the weight per foot of flat steel be estimated?

$$\frac{\text{Thickness in inches x Width in inches x 10}}{3} = \text{lbs/ft steel}$$

When estimating the weight for steel with multiple flat surfaces (S beams, wide flange beams, channels, angles, etc.) add the width of each flat surface together and insert the total width in the formula.

F. Other activity

Go through a metals catalog with students to show the types of metals available for project construction and their price.

G. Conclusion

It is important to understand how metals are sized when planning the project. Lengths and gauges are important when choosing the proper metal for the project to be constructed. Proper knowledge of metal specifications will help the student avoid wasting money when ordering the metal.

H. Competency

Explain how construction metal is dimensioned.

I. Answers to Evaluation

1. a
2. c
3. e
4. Three of the following: communicate with others, correct bill of materials, more efficient ordering, estimate costs more accurately.
5. 13.33 lbs per foot
6. c
7. g
8. d
9. b
10. e

UNIT IV - METALS Name ____________________

Lesson 2: Construction Metal Shapes and Sizes Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Sheet metal is less than __________ thick.

   a. 3/16"
   b. 3/8"
   c. 5/8"
   d. 3/4"
   e. 1"

2. Concrete structures often contain __________ to provide added strength to the structure.

   a. Metal pellets
   b. S beams
   c. Reinforcing bars
   d. Wide flange beams
   e. Channel iron

3. Which of the following would have the greatest wall thickness?

   a. Schedule 10 pipe
   b. Schedule 40 pipe
   c. Schedule 60 pipe
   d. Schedule 80 pipe
   e. Schedule 120 pipe

Complete the following short answer questions.

4. Why is it important to know the shapes and sizes of metal?

   a.

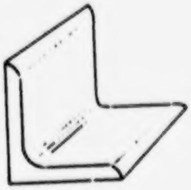
   b.

   c.

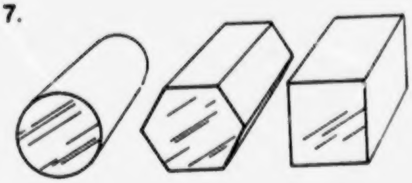
5. What is the estimate in lbs/foot for a piece of flat steel 1" x 4"? (Show your work below.)

Match the following shapes of metal to the correct name.

_____ 6.



_____ 7.



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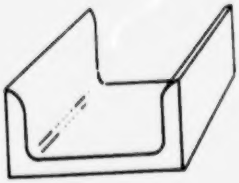

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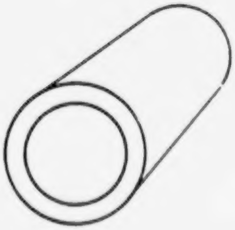
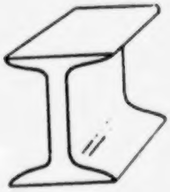


_____ 10.



a. Strip

b. Pipe

c. Angle

d. Channel

e. S beam

f. Flat

g. Bar

h. Sheet

Metal is produced in many different sizes and shapes. The agricultural worker must be familiar with construction metal so that the proper size and shape can be selected for each construction or repair job. The more common metal shapes are discussed below. Commonly available sizes are also given where appropriate.

Importance of Knowing Shapes and Sizes of Metal

It is important to know the shapes and sizes of construction metal for several reasons. It will be much easier to communicate with other workers if the correct terminology is used when referring to a shape of metal. The correct name will be helpful when preparing a bill of materials to make sure that the proper metal is ordered. Materials may be ordered in a more efficient manner since others will know the type of metal needed. Construction costs can be more accurately estimated since the prices of the correct types and sizes of metal will be used.

Measuring the Thickness of Construction Metal

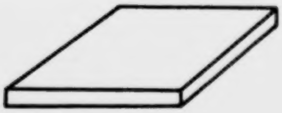
Smaller gauge numbers represent thicker metal while larger gauge numbers represent thinner metal. Ferrous and nonferrous metals are measured using different gauges. Ferrous metals are measured using the Manufacturer's Standard Gauge while nonferrous metals are measured using the American Standard Gauge. Therefore, 16 gauge aluminum will not be the same thickness as 16 gauge steel. (16 ga aluminum is .0508 inches thick; 16 ga steel is .0598 inches thick). Common gauge numbers and decimal equivalents for aluminum and steel are listed in Table 2.1. To avoid mistakes when ordering materials, always use the decimal equivalent with the gauge number.

Table 2.1 - Gauge Numbers and Decimal Equivalents for Aluminum and Steel

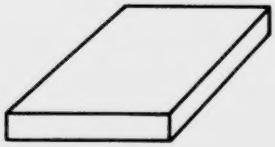
	Decimal Equivalent	
Gauge Number	Aluminum	Steel
18	.0403	.0478
16	.0508	.0598
14	.0641	.0747
13	.0720	.0897
12	.0808	.1046
11	.0907	.1196
10	.1019	.1345
7	.1443	.1793

Common Construction Metals

Sheets - Sheets are flat pieces of metal which are less than 3/16 inch thick. The thickness of a metal sheet is given by a gauge number. Sheets are commonly available in widths ranging from 24 to 72 inches. Standard lengths are 8', 10', 12', and 20'. The correct way to specify the size of a sheet of metal is by stating thickness x width x length (T x W x L).



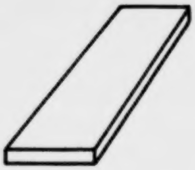
SHEET



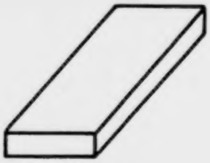
PLATE

Plates - Plates are flat pieces of metal which are equal or greater than 3/16 inch thick. Plate thickness is stated in fractional form. Plates are available in widths from 9 to 120 inches; however, the larger widths may not be commonly stocked by all suppliers. Plates are available in 8', 10', 12', and 20' lengths. Size is specified by stating thickness x width x length (T x W x L).

Strips - Strips are flat pieces of metal which are equal to or less than 3/16 inch thick. Strips are available in widths which range from 3/4 to 12 inches. Common lengths range from 16-20 feet. The correct way to specify the size of strips is by stating T x W x L.



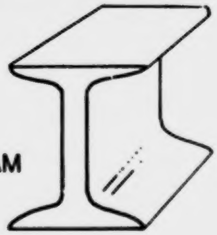
STRIP



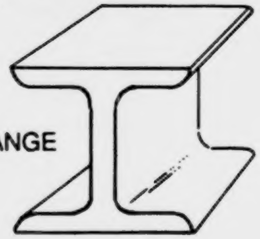
FLAT

Flats - Flats are similar to strips except that flats are 1/4 inch or more in thickness. Widths range from 3/8 to 8 inches. Flats are commonly available in 20 foot lengths. Size is specified by stating T x W x L.

S beams - S beams are often called "I" beams because they resemble the capital letter "I". The correct method of specifying an S beam is to state the symbol(s), the depth, the weight per foot, and finally the length. For example, a S3 x 5.7 x 20' beam is a standard S beam with a depth of 3 inches, weight of 5.7 lbs per foot, and a length of 20 feet. S beams are commonly available in 20' standard lengths although 40' and 60' lengths are also available.



S BEAM



WIDE FLANGE

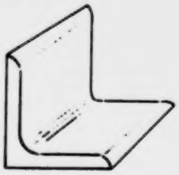
NOTE: Inside flange surfaces have little or no slope.

Wide flange beams - Similar in appearance to S beams, wide flange beams have wider flanges with little or no slope. The letter(s) W or WF are used to denote a wide flange beam.

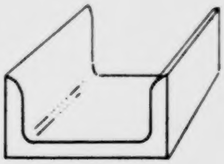
The correct method of specifying a wide flange beam is to state the symbol(s), the depth, the weight per foot, and finally the length. For example, W8 x 10 x 20' beam is a standard wide flange beam with a depth of 8 inches, weight of 10 lbs per foot, and a length of 20 feet. Wide flange beams are commonly available in 20' standard lengths although 40' and 60' lengths are also available.

Angle - An angle is a structural shape of metal which has two legs set at a 90 degree angle to each other. ⌟ is the symbol used to indicate an angle on drawings. The customary method of billing angles is to give the symbol, then the width of the longest leg, the width of the shortest leg, the thickness, and finally the length. For example: ⌟ 2" x 1 1/2" x 1/8" x 21' would represent an angle with one 2-inch leg, one 1 1/2-inch leg, 1/8 inch thick and 21 feet long. Angles are most commonly available in 20' standard lengths although 40' and 60' lengths are also available.

> NOTE: When the legs are equal in length, both lengths should be stated. For example: ⌟ 2" x 2" x 1/4" x 21'.



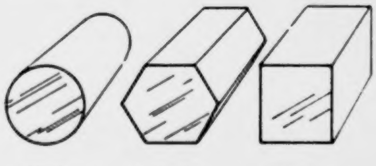
ANGLE



CHANNEL

Channel - Channel is a structural shape that looks like a wide flange beam that has been cut in half through the long part of the web. The letter "C" is used to represent a channel on drawings. (NOTE: Occasionally the symbol [is used.) The customary method of specifying a channel is to state the symbol, the depth, the weight per foot, and finally the length. For example, a C15 x 50 x 20' channel has a depth of 15 inches, weight of 50 lbs per foot, and a length of 20 feet. Channels are commonly available in 20' standard lengths although 40' and 60' lengths are also available.

Bars - Bars are solid pieces of metal which are available in round, square, and hexagonal shapes. The size of round and hexagon bars is based on diameter and length, while the size of square bars is based on thickness, width, and length. Bars are normally available in 20 foot lengths.

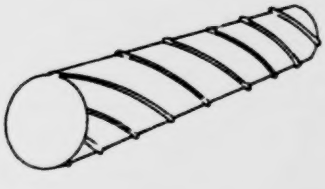


Round Hexagon Square

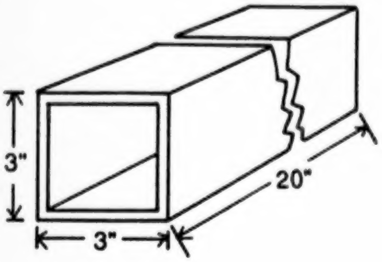
Reinforcing bars (Re-bars) - Reinforcing bars are intended for use as reinforcement in concrete structures. The bars are ribbed in order to prevent slipping once the concrete is dry. Reinforcing bars are sized by diameter and length. Diameter is stated as a whole number according to the following convention. Reinforcing bars are available in 20, 30, and 40 foot lengths. Table 2.2 below lists the diameter of each size of reinforcing bar.

Table 2.2 - Reinforcing Bar Specifications

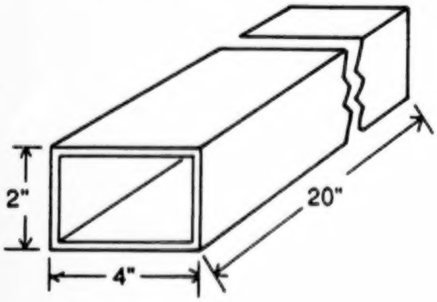
Bar Number	Diameter in Inches
3	3/8
4	1/2
5	5/8
6	3/4
7	7/8
8	1



Structural steel tubing - Structural steel tubing is often used as a building material. It is available in square and rectangular shapes. Structural tubing has many advantages as a building material, including strength and light weight. The correct way to specify square structural tubing is to state the outside dimensions x (wall thickness) gauge x length. The correct way to specify rectangular structural tubing is to state the long outside dimension x short inside dimension x wall thickness (gauge) x length. For example, the figure below is a 3" x 3" x .065 x 20' square structural tube.

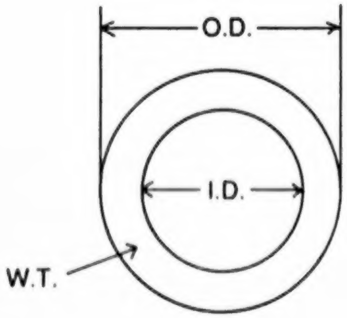


The figure below is a piece of 4" x 2" x .065 x 20' structural tubing.



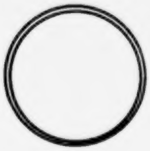
Pipe - Metal pipe is a tubular product intended for conveying water, air, steam, fuel, etc. Metal pipe has been widely used in agricultural construction and repair due to its wide availability. Pipes are generally available in black (unfinished) or galvanized (zinc coated) form. Galvanized pipe is often used in water systems due to its resistance to corrosion. Proper ventilation must be provided when welding or cutting galvanized pipe. The zinc that is liberated during these operations is hazardous. The illustration below shows important terms associated with the measurement of pipe.

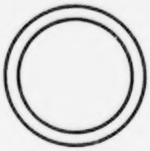
O.D. = Outside Diameter
I.D. = Inside Diameter
W.T. = Wall Thickness

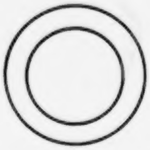


The size of a metal pipe is determined by its nominal inside diameter and its wall thickness. For pipes less than 14 inches in diameter, the actual inside diameter is usually larger than the nominal inside diameter. For example, a 1/2-inch, standard (schedule 40) steel pipe has an actual inside diameter of 0.622 inches.

The same nominal size of pipe will be available with various standard wall thicknesses. Wall thickness is denoted by various schedule numbers (10, 20, 30, 40, 60, 80, 100, 120, 140, 160). The larger the schedule number, the greater the wall thickness of the pipe. For example, a 1/2 inch schedule 40 pipe has a wall thickness of 0.109 inches while a 1/2 inch schedule 80 pipe has a wall thickness of 0.147 inches. Schedule 40 is the most common wall thickness schedule and is often called standard pipe. The wall thickness of a pipe is increased by reducing the actual inside diameter of the pipe. This is illustrated below.


SCHEDULE 40


SCHEDULE 80


SCHEDULE 160

	Schedule 40	Schedule 80	Schedule 160
Actual I.D	2.067	1.939	1.689
Actual W.T.	.154	.218	.343
Actual O.D.	2.375	2.375	2.375

Table 2.3 shows standard sizes of pipe which are commercially available. Pipe is normally sold in lengths of 21 feet.

Table 2.3 - Common Pipe Sizes and Specifications

Nominal Size	Outside Diameter(inches)	Actual Inside Diameter (Inches)		
		40	80	160
1/8	.405	.269	.215	---
1/4	.540	.364	.302	---
3/8	.675	.493	.423	---
1/2	.840	.622	.546	.466
3/4	1.050	.824	.742	.614
1	1.315	1.049	.957	.815
1 1/2	1.900	1.610	1.500	1.338
2	2.375	2.067	1.939	1.689
2 1/2	2.875	2.469	2.323	1.885
3	3.500	3.068	2.900	2.625
3 1/2	4.00	3.548	3.364	---
4	4.50	4.026	3.826	3.438
5	5.562	5.047	4.813	4.313
6	6.625	6.065	5.761	6.187

Careful study of the preceding table will reveal one advantage of pipe as a construction material. One standard size of pipe will normally fit inside the next largest size of the same schedule pipe. This makes it possible to construct telescoping devices such as jack stands and adjustable wagon tongues without machining the parts. Although tolerances are not exact, the fit obtained will usually be satisfactory.

Estimating the Weight per Foot of Flat Steel

Metal is sold by the pound. Most distributors list the weight per foot of each piece of metal that they sell in their catalog. Agricultural workers, however, often need a way to estimate weight and cost when distributor's information is not readily available. The following formula can be used to estimate the weight per foot of flat steel stock. The formula should only be used to estimate the weight; refer to distributor's literature to determine the weight of the material that you will actually be billed.

$$\text{Lbs per foot for steel} = \frac{\text{Thickness (inches)} \times \text{Width (inches)} \times 10}{3}$$

Example: Estimate the weight per foot of 1" x 6" flat steel.

Solution:

$$\frac{T \times W \times 10}{3} = \frac{1 \times 6 \times 10}{3} = \frac{60}{3} = \text{20 lbs. per foot}$$

The estimated weight is 20 lbs per foot. This is an excellent estimate: one distributor's catalog lists the weight per foot for the same size steel as 20.40 lbs while another distributor's catalog lists the weight per foot as 20.42 lbs. The weight of the essentially flat steel shapes such as S beams, wide flange beams, channels, etc., can also be estimated with this formula.

> NOTE: Items which do not have a uniform thickness such as S beams, channels, etc. will provide less accurate estimates using this formula.

To use the formula on a piece of steel with more than one flat surface, simply add the widths of all the flat surfaces together and inset the total width into the weight formula.

Example: Estimate the weight per foot of a 2" x 2" x 1/4" steel angle.

Solution: 2" leg + 2" leg = 4" total width

$$\frac{T \times W \times 10}{3} = \frac{.25 \times 4 \times 10}{3} = \text{3.33 lbs. per foot}$$

Again, the estimated weight per foot of 3.33 lbs is close to the weight per foot of 3.19 lbs listed in a distributor's catalog.

Summary

Metals are available in different thicknesses, lengths, and shapes. It is important to know the types of metal available for project construction to allow for better communication and a reduced cost of construction. Knowing the characteristics of each of the types of construction metal will allow you to avoid waste of materials or ordering the wrong type of metal for the project.

Credits

Brandt, Daniel A. Metallurgy Fundamentals. South Holland: The Goodheart-Willcox Company, Inc., 1985.

Morrisey, Thomas J. Introductory Metalworking. Cincinnati: South-Western Publishing Co., 1983.

Steel Catalog and Reference Book. Brooksville, FL: J.H. Jackson & Associates, Inc., 1979.

Walker, John R. Modern Metalworking. South Holland: The Goodheart-Willcox Company, Inc., 1985.

Lesson 3: Preventing Weld Failure

Objective: The student will be able to identify and remove stress raisers that cause weld failure.

Study Questions

1. **What is weld failure?**
2. **What are stress raisers?**
3. **How do stress raisers affect fatigue strength?**
4. **What preparations can be made before welding to eliminate weld failure?**
5. **How can weld failure be prevented during welding?**

Reference

1. Handout
    a) HO 3.1: Preventing Weld Failure

Lesson 3: **Preventing Weld Failure**

TEACHING PROCEDURES

A. Review

Review the previous lesson on dimensioning construction metal.

B. Motivation

A piece of wire should be used to illustrate the effect of fatigue strength. Bend the wire back and forth in the same place until it breaks. The constant pressure on the bend in the wire will illustrate the affect of fatigue strength on metal.

C. Assignment

D. Supervised study

E. Discussion

1. A project that will be subject to a lot of stress and repeated loads should be planned carefully to prevent failure in the welds. Discuss with the class the importance of preventing weld failure.

   What is weld failure?

   a) Weld failure is the breakdown of the weld metal due to structural or mechanical defects in the weld.
   b) Weld failure reduces fatigue strength, which is the ability of a metal to avoid breakdown after repeated stress.

2. Any time that an unnatural break or scratch in the structure of metal occurs, the strength of the metal will be reduced. Discuss how stress raisers can be reduced or avoided. Stress how careful planning and good workmanship will eliminate most stress raisers.

   What are stress raisers?

   a) Stress raisers are unnatural breaks or scratches in the structure of the metal.
      1) Bolt holes
      2) Corners
      3) Lack of fusion in the base metal
      4) Notches or grooves
      5) Re-entry cuts
      6) Rivet holes
      7) Tool marks
      8) Undercut and overlap of welds
      9) Unfilled arc craters
   b) Stress raisers cause localized concentration of stress when a load is applied.

3. Ask the class how stress raisers affect the strength of the metal in the project. To illustrate this, the instructor could use a glass cutter to "nick" a piece of glass which then can easily be broken on the "nicked" line. Ask them to describe why this effect would be present.

   How do stress raisers affect fatigue strength?

   a) Stress raisers reduce the metal's resistance to fatigue failure.
   b) When repeated loads are applied, the metal will tend to crack where stress raisers are present.

4. If correct welding procedures are followed, many sources of stress can be avoided. If properly done, the weld should be stronger than the base metal rather than presenting a stress problem. Ask the class how weld failure can be avoided before welding begins.

   What preparations can be made before welding to eliminate weld failure?

   a) Clean the base metal of dirt and oxides.
   b) Select the proper joint design and fit.
   c) Select the correct welding process at the correct temperature.
   d) Apply preheating treatments when necessary to prevent distortion and internal stress.
   e) Select proper filler metal for the base metal. (Match carbon content.)

5. Several precautions can be taken during the welding process to prevent weld failure. Ask students which types of weld defects would cause a weld to fail under stress.

   How can weld failure be prevented during welding?

   a) Avoid undercutting and overlapping of the weld bead.
   b) Eliminate unfilled craters and incomplete weld beads.
   c) Use proper weld placement. Short, alternate beads should be used when possible.
   d) Avoid slag inclusion and porosity.
   e) Avoid cold overlap when MIG welding.

F. Other activities

1. Prepare a teaching aid of metal pieces that contain stress raisers, as well as pieces without stress raisers.

2. Have students identify stress raisers in projects or equipment in the shop.

G. Conclusion

The number of stress raisers in a project should be kept to a minimum. Stress raisers lower the fatigue strength of the metal, thus making the project weaker. Several precautions can be taken to prevent welds in the project from failing under stress.

H. Competency

Remove stress raisers.

I. Answers to Evaluation

1. b
2. d
3. Will reduce resistance and cause the metal to crack.
4. Three of the following: clean base metal, proper joint and fit, correct welding procedure, preheating treatment, select proper filler metal
5. Two of following: avoid overlap and undercut, eliminate unfilled craters and incomplete welds, proper weld placement, and avoid cold overlap when MIG welding.

UNIT IV - METALS Name ______________

Lesson 3: Preventing Weld Failure Date ______________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The breakdown of the weld metal due to structural or mechanical defects is called ______________.

   a. Fatigue strength
   b. Weld failure
   c. Tensile strength
   d. Stress raiser
   e. Compression strength

2. What causes localized concentration of stress when a load is applied?

   a. Weld failure
   b. Fatigue strength
   c. Compression strength
   d. Stress raiser
   e. Tensile strength

Complete the following short answer questions.

3. What effects do stress raisers have on fatigue strength?

4. Name three prewelding preparations that can be followed to reduce weld failure.

   a.

   b.

   c.

5. Name two ways that weld failure can be prevented during welding.

   a.

   b.

Weld Failure

Weld failure is the breakdown of the weld metal due to structural or mechanical defects in the weld. Proper prewelding and postwelding procedures should be used in order to reduce the chance of weld failure. Weld failure reduces fatigue strength of the base metal being welded. It can cause serious structural problems for the project. Fatigue strength is the ability of a metal to avoid breakdown after repeated stresses.

If stress is continuously applied to the metal, the metal begins to lose its ability to counteract the forces of stress, thus creating "weak spots" in the project. If the project being constructed is one that requires a lot of movement, the reduction in fatigue strength could cause the equipment to become dangerous or inoperable.

Stress Raisers

Irregularities within a weld or on the surface of the metal that cause the fatigue strength of a metal to be reduced are referred to as stress raisers. Stress raisers cause localized concentration of stress when a load is applied. When stress is applied to the area in which a stress raiser exists, it will eventually cause the metal in that area to break down.

Rivet holes, bolt holes, tool marks, scratches on the metal's surface, undercut and overlapped welds, lack of fusion in the base metal, unfilled arc craters, notches or grooves, cuts made for re-entry, corners, etc. are all considered stress raisers. Not all stress raisers can be avoided, but they should be considered when designing the project to minimize their effect on the structural soundness of the project. Corners in the project, as well as bolt and rivet holes should be located where their affect on fatigue strength will be lessened. Many of the defects in the actual welds made on the project can be avoided by using correct welding procedures.

Stress Raisers Affect Fatigue Strength

If stress raisers are not eliminated or reduced, they will have a serious affect on the metal's ability to resist fatigue failure. Fatigue failure will occur when repeated loads are applied to areas in which stress raisers exist. If a poor quality weld exists in an area of localized stress, the weld or metal surrounding it will develop a crack that will worsen each time the load is applied.

Weld Preparations

Most stress raisers can be avoided before project construction begins. Careful planning of the project will eliminate many of the stress raisers such as placement of corners and holes necessary for the project to be functional. The base metal should be properly prepared before welding occurs. It should be free of dirt and oxides. The presence of dirt and oxides on the base metal will result in poor quality welds by weakening the filler metal of the weld through porosity and slag inclusion. The proper joint design and fit should be selected for the project. Select the correct welding process at the correct temperature to avoid distortion and internal stress. Preheating may be needed to provide a uniform metal temperature in the weld area to prevent structural weaknesses in the metal. Select the proper electrode based on the carbon content of the metal to be welded.

Preventing Weld Failure During Welding

Many stress raisers can be eliminated if the correct technique is followed during the welding process. Weld defects, such as undercut, overlap, slag inclusion, and porosity, should be avoided during welding. Proper techniques in weld placement should be followed to avoid poor welds.

Since lap joints are less resistant to fatigue failure than butt or T-fillet joints, they should be avoided when possible. Eliminate unfilled craters and incomplete weld beads, since they will greatly reduce the strength of the joint being welded. Proper weld placement is important. Short, alternate beads should be used whenever possible to control distortion. As few welds as possible should be made. Avoid excessive filler metal in the joint being welded. Extra filler metal in the weld does not increase the strength of the weld; it only increases the amount of stress present in the weld area. Avoid cold overlap when MIG welding.

Summary

All stress raisers may not be able to be eliminated. But, through careful planning and the use of the proper welding technique their effect can be minimized, making the project more useful and increasing the life of the project.

Credits

Brandt, Daniel A. Metallurgy Fundamentals. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

Jefferson, T. B; Gorham Woods. Metals and How to Weld Them. 3rd ed. Cleveland, OH: James F. Lincoln Arc Welding Foundation, 1983.

Morrisey, Thomas J. Introductory Metalworking. Cincinnati, OH: South-Weston Publishing Co., 1983.

Lesson 4: Identifying Metal Fasteners

Objective: The student will be able to identify the types of metal fasteners used in project construction.

Study Questions

1. **What are some common economical metal fasteners?**
2. **What nuts are available for use?**
3. **What washers are available for use?**
4. **What special fasteners are used for metal?**

Reference

1. Handout
    a) HO 4.1: Metal Fasteners

Lesson 4: **Identifying Metal Fasteners**

TEACHING PROCEDURES

A. Review

Review the previous lesson on stress raisers. Review the fasteners discussed in Agricultural Science I and II Core Curriculum.

B. Motivation

Have several types of fasteners displayed in the front of the classroom. Present several situations where a fastener would be needed. Have the students pick which could be used and give their reasons for their choice.

C. Assignment

D. Supervised study

E. Discussion

1. There are several common fasteners used in project construction. The cost of fasteners will vary for several reasons. Ask students to think of as many different fasteners as they can and list them on the board. Discuss if these fasteners are economical. Place items listed below in a plastic bag. Ask students to identify as many of the items as they can.

   What are some common economical metal fasteners?

   a) Machine bolts
   b) Carriage bolts
   c) Machine screws
   d) Sheet metal screws
   e) Set screws
   f) Cap screws
   g) Stud bolts
   h) Tap bolts
   i) Thread-forming screws
   j) Drive screws
   k) Thumb screws

2. Ask students to list and discuss those nuts used with the above types of fasteners. Discuss advantages and disadvantages of each.

   What nuts are available for use?

   a) Hex nuts
   b) Self-locking nuts
   c) Jam nuts
   d) Slotted or castellated nuts
   e) Cap (acorn) nuts

f) Wing nuts
g) Inserts

3. Ask students to list those types of washers used with the fasteners listed above. Discuss when each will be used.

What washers are available for use?

a) Regular washers
b) Lock washers

4. Not all fasteners are nuts and bolts. There are several types of fasteners available that will provide special uses for agricultural construction. Special fasteners are used for specific jobs. Ask students where these various fasteners would be used.

What special fasteners are used for metal?

a) Rivets
b) Dowel pins (rolled pins)
c) Cotter pins
d) Retaining rings
e) Keys
f) Adhesives

F. Other activities

1. Prepare a panel that displays samples of the fasteners described in this lesson.

2. Secure or make samples of threaded and non-threaded fasteners applied to an actual job. Mount them on a display panel.

3. Organize the storage of fasteners in the school laboratory. Count them and keep them inventoried for future reordering.

G. Conclusion

When selecting fasteners for a specific project, consider the purpose of the project and the type, purpose, and cost of the fastener. By selecting the correct fastener, you can meet approved standards and be assured of the safety of the project.

H. Competency

Identify common metal fasteners.

I. Answers to Evaluation

1. b
2. i
3. e
4. g
5. c
6. a
7. j
8. f
9. d
10. h

UNIT IV - METALS

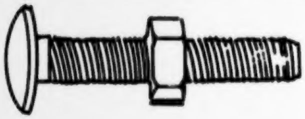
Name ____________________

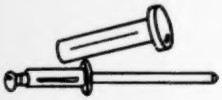
Lesson 4: Identifying Metal Fasteners

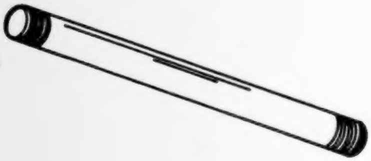
Date ____________________

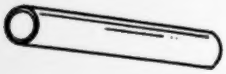
EVALUATION

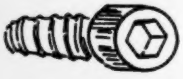
Place the letter on the blank that corresponds to the correct name for the picture.

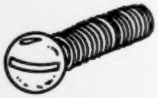
___ 1. 

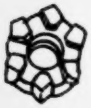
___ 2. 

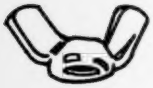
___ 3. 

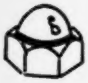
___ 4. 

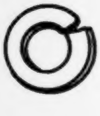
___ 5. 

___ 6. 

___ 7. 

___ 8. 

___ 9. 

___ 10. 

A. Machine screw

B. Carriage bolt

C. Cap screw

D. Acorn nut

E. Stud bolt

F. Wing nut

G. Dowel pin (rolled pin)

H. Lock washer

I. Rivet

J. Castellated nut

IDENTIFYING METAL FASTENERS

HO 4.1

A wide variety of metal fasteners are available, depending on the type of project and the metal being joined together. It is important to select the correct fastener for the project in order to provide workability and durability. The types of fasteners for metal are discussed below.

Machine bolts - Machine bolts are used where precision is not required and close tolerances are not observed. The upper portion of the shaft on a machine bolt is not threaded. Hex nuts and washers are used to tighten the machine bolt once it is in place.

FIGURE 4.1 - Machine bolt

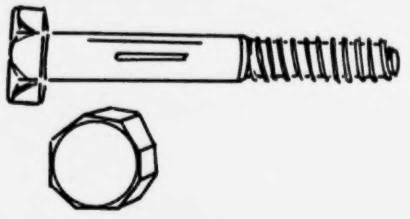
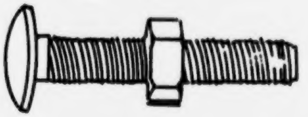


FIGURE 4.2 - Carriage bolt



Carriage bolts - Carriage bolts are used to fasten wood to metal. They have a rounded head with a small section of square body directly beneath the head of the bolt. When tightening the hex nut, the square section will sink into the wood to prevent the bolt from turning.

Machine screws - Machine screws are used in general assembly to attach thin metal to thick metal. The shaft of the machine screw is entirely threaded and may be used in a tapped or untapped hole. The heads may be slotted or recessive.

FIGURE 4.3 - Machine screws

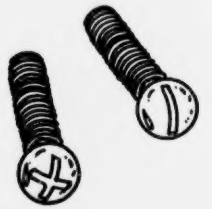
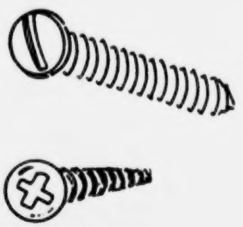


FIGURE 4.4 - Sheet metal screws



Sheet metal screws - Sheet metal screws are self-tapping screws that form their own threads in soft metals as they are being tightened. They are used to join sheet metal together or sheet metal to wood. A variety of head and point styles are available, depending on the job to be done.

Setscrews - Setscrews are used to hold or fasten a part (e.g., pulleys or shafts) in place. They may have a square head, though many times they are headless and will set below the surface of the metal. A variety of points are available, depending on the type of application for which the setscrew is needed. An allen wrench is usually required to adjust a headless setscrew.

FIGURE 4.5 - Setscrews

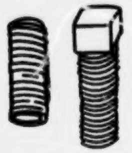
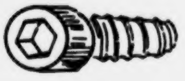


FIGURE 4.6 - Cap screws



Cap screws - Cap screws are used for assemblies requiring higher quality and a more finished appearance. They are available in National Coarse or National Fine threads. Cap screws are not threaded the entire body of the screw. To install a cap screw, you insert the screw through an unthreaded hole and screw into a threaded hole.

Stud bolts - Stud bolts are used to connect two pieces when one threaded hole is available. One end is threaded into the tapped hole, while the other end of the stud bolt is slid through an unthreaded hole in which a washer and a nut is used on the other end to tighten the bolt. A stud bolt may be threaded the entire body of the bolt or on both ends with the middle part of the body being solid.

FIGURE 4.7 - Stud bolts

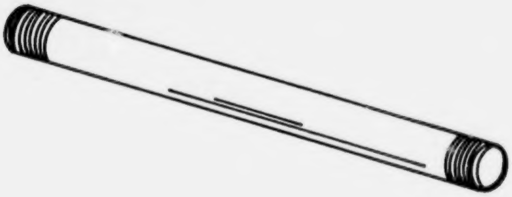
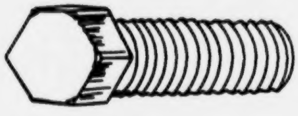


FIGURE 4.8 - Tap bolts



Tap bolts - Tap bolts are used either in a threaded hole or an unthreaded hole. The entire length of the bolt is threaded. A hex nut and washer are used when the bolt is extended through an unthreaded hole. If the hole is threaded, no nut and washer is necessary.

Thread-forming screws - Thread-forming screws form their own threads when they are driven into the metal. The hole in which they are placed does not have to be tapped.

FIGURE 4.9 - Thread-forming screws

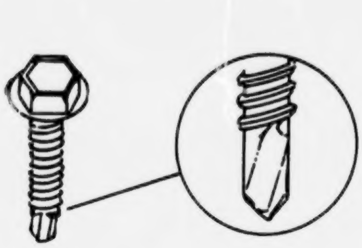
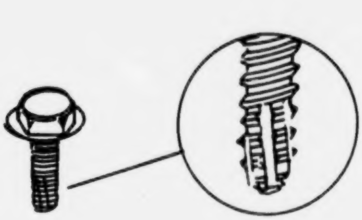


FIGURE 4.10 - Drive screws



Drive screws - Drive screws are used for permanent assembly. The screw is lined up and hammered into the hole. Threads are angled to prevent the screw from pulling out.

Thumb screws - Thumb screws are used when frequent loosening and tightening of the screw is necessary when proper torque is not a concern. A thumb screw does not require a screwdriver since it can be adjusted easily with the thumb and forefinger.

FIGURE 4.11 - Thumb screw

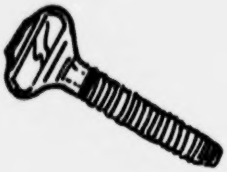
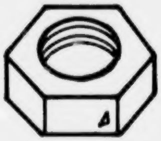


FIGURE 4.12 - Hex nut



Hex nuts - Hex nuts are used to tighten bolts to the metal they are connecting. They are generally used in combination with washers to tighten a connection.

Self-locking nuts - Self-locking nuts are machined with slight deformities in their workmanship that prevent them from working loose during operation or vibration.

FIGURE 4.13 - Self-locking nut

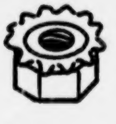
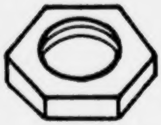


FIGURE 4.14 - Jam nut



Jam nuts - Jam nuts are used to hold a regular hex nut in place when it is exposed to excessive vibration or machine movement. Jam nuts are thinner than regular nuts and may be placed before or after the regular nut on the bolt.

Slotted or castellated nuts - Slotted and castellated nuts are used on parts with excessive movement or vibration. Slots are cut on top of the nut and a cotter pin is inserted through a hole in the bolt and through a slot in the nut. A cotter pin prevents the nut from loosening during movement or vibration.

FIGURE 4.15 - Castellated nut

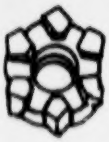
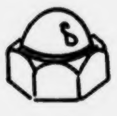


FIGURE 4.16 - Cap (acorn) nut



Cap (acorn) nuts - Cap nuts are used to conceal the end of the bolt and improve the appearance of the project. Cap nuts are useful when the sharp edges of the bolt should not be exposed.

Wing nuts - Wing nuts are used where torque is not a concern or frequent adjustments need to be made. Wing nuts do not require a wrench for tightening since they can be tightened with the thumb and forefinger.

FIGURE 4.17 - Wing nut

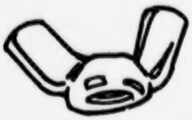
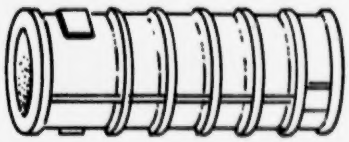


FIGURE 4.18 - Insert



Inserts - Inserts are used to replace stripped or damaged threads. They may also be used to strengthen threads in plastic materials or very soft metal. The insert is placed inside the existing hole and the bolt or screw is turned into the grooves of the insert. Inserts are also used as an anchor in blind holes.

Regular washers - Regular washers are used to prevent bolts or screws from pulling through soft materials and to lock the bolt in place. They provide a larger surface for the heads of bolts and screws to tighten against, thus improving the holding power of the bolt.

FIGURE 4.19 - Regular washer

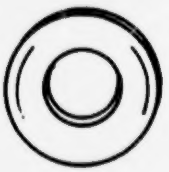
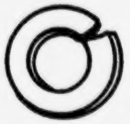


FIGURE 4.20 - Lock washer



Lock washers - Lock washers are used to lock the bolt in place. A split causes the ends of the washer to bow away from each other to allow the washer to put pressure against the nut, thus preventing it from working loose during vibration or movement.

Rivets - Rivets are used to permanently attach metals. Holes are made in both pieces to be joined and the rivet is inserted into the hole and flattened out, to hold the metal in place. Two types of rivets may be used: common rivets and pop rivets. When using common rivets, the rivet is inserted through both holes and the bottom is flattened out to prevent it from pulling back through the hole. A pop rivet is used when the hole is not accessible enough to hammer out a common rivet. Pressure exerted by the rivet tool will expand the end of the rivet to join the metals together.

FIGURE 4.21 - Rivets

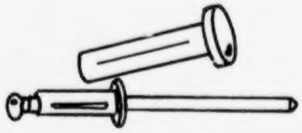
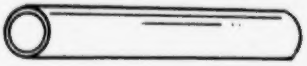


FIGURE 4.22 - Dowel pin



Dowel pins (rolled pin) - Dowel pins are used to join matching parts to hold them in place. The dowel pin may or may not have a head and is removable to allow parts to be exchanged or repaired.

Cotter pins - Cotter pins are inserted into a slotted nut or a hole in a bolt to hold it in place. One end is put through the bolt and the other end is put through the slot of the nut. Cotter pins are useful when a bolt is used to hold metal parts in alignment and must be removed frequently.

FIGURE 4.23 - Cotter pin

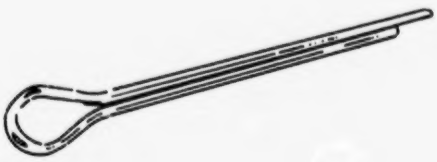
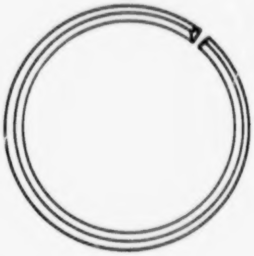


FIGURE 4.24 - Retaining ring



Retaining rings - Retaining rings are used to hold a part in place and require a special pair of pliers in order to seat them. They are generally seated into a groove, though there are self-locking types that do not require a groove.

Keys - Keys are used to prevent a part from rotating. They are seated into a groove on the shaft that is the same shape as the key. The key must be made out of the correct material.

FIGURE 4.25 - Keys

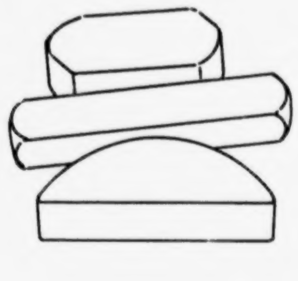
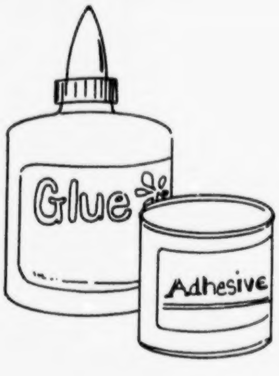


FIGURE 4.26 - Adhesives



Adhesives - Adhesives are used to join metals together when little or no heat will be present in the project. When the metal is exposed to high heat, the adhesive will tend to deteriorate or fail. Adhesives are sometimes used to strengthen threaded joints.

Summary

A wide variety of fasteners are available for use when working with metal in agricultural construction. A knowledge of the types of fasteners will assist you in constructing a project that is safe, while using the most economical fasteners.

Credits

Agricultural Science I Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

Brandt, Daniel A. Metallurgy Fundamentals. South Holland: The Goodheart-Willcox Company, Inc., 1985.

Morrisey, Thomas J. Introductory Metalworking. Cincinnati: South-Western Publishing Co., 1983.

Walker, John R. Modern Metalworking. South Holland: The Goodheart-Willcox Company, Inc., 1985.

UNIT IV - METALS

Lesson 5: Identifying the Hardness Grade of a Bolt

Objective: The student will be able to correctly identify the hardness grade of a bolt.

Study Questions

1. **Why do we need to be able to identify the hardness of a bolt?**
2. **What are some general rules to follow when determining whether to select a soft or hard bolt for a particular application?**
3. **What two factors determine the hardness of a steel bolt?**
4. **How can you determine the hardness of a non-metric bolt?**
5. **How can you determine the hardness of a metric bolt?**

Reference

1. Handout
    a) HO 5.1: Identifying the Hardness Grade of a Bolt

Lesson 5: Identifying the Hardness Grade of a Bolt

TEACHING PROCEDURES

A. Review

Review of the previous lesson on metal fasteners.

B. Motivation

A student participation type of demonstration will be used as the motivation for this lesson. Prior to class, the instructor will need to:

1. Obtain selection of small (less than or equal to 1/4") bolts of various SAE and metric hardness grades.
2. Drill and tap two "blind" holes (corresponding to the size of bolts obtained) in each of two different pieces of square bar stock.
3. Finger-tighten two different SAE hardness grades of bolts in one bar and two different metric property class bolts in the other bar.
4. Identify each bolt by placing a numbered piece of masking tape on the head of each bolt.
5. Obtain torque-wrench and proper socket(s).
6. Provide a method for securing bars to an immoveable object (C-clamps, machinist's vise, etc.).

After the review of the previous lesson, the instructor should:

1. Have students put on proper eye protection.
2. Pass the bars containing the bolts around the class. Ask the students if they see any differences in the bolts. (If the bolts are properly selected, the students will not.)
3. Place one of the bars in a vise or other holding device.
4. Ask for three volunteers. Assign one student to torque each bolt until it breaks, one student to verify the torque reading, and one student to record the breaking torque values for each bolt on the board.
5. Ask the students why the bolts broke at different torque values. Lead them to state that they broke at different values because of differences in hardness.
6. Tell the class that the purpose of today's lesson is to learn how to identify the hardness of a steel bolt.

C. Assignment

D. Supervised study

E. Discussion

1. Bolts of the same length and thread size can have quite a difference in the hardness grades. Ask the students why it is important to be able to determine the hardness of a bolt.

   Why do we need to be able to identify the hardness of a bolt?

   a) So that we can select the correct hardness of bolt for the requirements of a particular situation.
   b) To prevent bolt failure and equipment damage.

2. It is important to know when a hard or soft bolt should be used. Discuss general rules which should be followed to determine the hardness of a bolt to be used in a particular situation. Discuss rules that help determine which should be used.

   What are some general rules to follow when determining whether to select a soft or hard bolt for a particular application?

   a) Use harder bolts if torque values are specified and use softer bolts when torque values are not specified.
   b) Always replace an original bolt with a bolt of the same hardness.
   c) When replacing machinery and/or equipment bolts, consult operator or service manual if in doubt about bolt hardware.

3. Special characteristics of the metal used to make a bolt will determine its hardness. Ask students what two factors determine bolt hardness.

   What two factors determine the hardness of a steel bolt?

   a) Carbon and alloy content
   b) Heat treatment process

4. Metric and non-metric bolts are marked and classified differently. Discuss with the students how the hardness of a non-metric bolt can be determined. Provide examples and have the class arrange the bolts from softest to hardest grade.

   How can you determine the hardness of a non-metric bolt?

   a) Check the SAE hardness grade markings on the head of the bolt. (As the number of marks on the head of the bolt increases, so does the hardness of the bolt.)
   b) Exact tensile strength can be determined by looking up the SAE hardness grade specification in a chart like the one in HO 5.1.

   NOTE: Uncover the SAE grade markings on the two broken, non-metric bolts used in the motivation. Refer to the breaking torque values on the board and reinforce the fact that as the number of SAE grade markings increases, so does the hardness of the bolt.

5. Ask the students how the hardness of a metric bolt can be determined. Discuss how this system of classification is different from a non-metric bolt. Provide examples and have the class arrange the bolts from softest to hardest grade.

   How can you determine the hardness of a metric bolt?

   a) Check the property class number on the head of the bolt.
   b) The hardness of a metric bolt increases as the property class number increases. Likewise, the hardness decreases as the property class number decreases.

   NOTE: Uncover the property class numbers on the two broken metric bolts. Refer to the breaking torque values on the board and reinforce the fact that as the property class number increases, so does the hardness of the bolt.

F. Other activities

1. Prepare a display of bolts.

2. Use catalog to illustrate price difference of metric and non-metric bolts.

3. Use piece of equipment to illustrate where classes of bolts are used.

G. Conclusion

It is very important to match the hardness of a bolt to the particular situation. This will prevent bolt failure and/or equipment damage. Bolt hardness is determined by tensile strength which is a function of a) carbon and alloy content and b) heat treatment process. Non-metric bolts are graded for hardness using the Society of Automotive Engineers (SAE) system. The more markings on the head of the bolt, the harder the bolt. Metric bolts are graded for hardness using property class numbers. The higher the number, the harder the bolt.

H. Competency

Identify the hardness grade of a bolt.

I. Answers to Evaluation

1. b
2. c
3. b
4. c
5. a
6. d
7. b
8. Softer bolts are often used so that in the event of equipment failure, they will shear and prevent further damage to the equipment. If a harder bolt than is recommended is used, extensive equipment damage may result.
9. manufacturer, repair manual
10. Use hard bolts if torque values are given, soft bolts if no torque value is given.

UNIT IV - METALS Name ____________________

Lesson 5: Identifying the Hardness Grade of a Bolt Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The hardness of a steel bolt is determined by its ______________.

   a. Compression strength
   b. Tensile strength
   c. Torsional strength
   d. Length
   e. Ductility

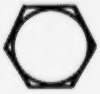
2. The hardness grade of a non-metric bolt can be found on the ______________.

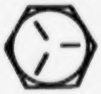
   a. Shaft
   b. Threads
   c. Head
   d. Collar
   e. Is not located on the bolt

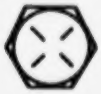
3. The hardness of a metric bolt can be determined by the ______________.

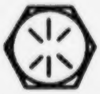
   a. Number of marks on the head
   b. Property class stamped on the head
   c. Fraction on the shank
   d. Package it was bought in
   e. Calling the manufacturer

Match the following bolts with the correct tensile strength by placing the letter of the correct tensile strength in the blank next to the question number.

____ 4. 

____ 5. 

____ 6. 

____ 7. 

a. 120,000 psi

b. 150,000 psi

c. 65,000 psi

d. 140,000 psi

Complete the following short answer questions.

8. Why is the hardness of a bolt important when repairing agricultural machinery and equipment?

9. Where can you find out what the hardness grade of a bolt for a repair job, if you do not have the old bolt?

10. What general rule should be followed to determine if a hard or soft bolt should be used?

Hardness Grade of a Bolt

Bolts are manufactured in various degrees of hardness ranging from very soft to extremely hard. When selecting bolts, it is very important to match the hardness of the bolt to the service requirements of that particular application. Improper bolt selection can result in bolt failure or expensive equipment damage. For example, the drive train of a pto-powered agricultural implement such as a hay baler, or a rotary mower, has connections which are joined by soft bolts. These bolts are designed to be the weakest link in the drive train. When excessive force is exerted, these bolts shear first. This disconnects the implement from the power source (tractor pto) and prevents damage to expensive tractor and/or implement components. However, if the soft bolts are replaced with extremely hard bolts, this safety factor will be eliminated and expensive equipment damage may result.

Rules

As a general rule, softer bolts can be used in non-critical applications where torque (bolt tightness) values are not specified. This includes many project construction applications. Harder bolts should be used, however, when torque values are specified. When repairing equipment and machinery, it is a good practice to always replace the original bolt with a bolt of the same hardness. When in doubt, consult the operation or repair manual to determine to correct bolt hardness.

Factors Affecting Hardness

The hardness of a steel bolt is determined by its tensile strength. Tensile strength is the amount of pressure per square inch (psi) that the bolt can withstand before it is pulled apart. The tensile strength, and thus the hardness, of a steel bolt is a product of (1) the carbon and alloy content of the bolt and (2) the heat treatment process that the bolt has undergone. Combinations of these two factors can be varied to produce bolts of many different hardnesses.

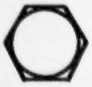
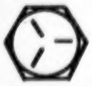
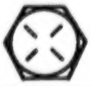
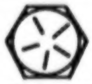
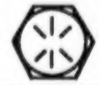
Non-metric Bolt Hardness Grades

The Society of Automotive Engineers (SAE) has established a standard system for grading the hardness of steel bolts. The SAE hardness grade of a particular steel bolt can be determined by looking at the grade marks on the head of the bolt. The tensile strength of the bolt increases as the number of marks increases. Table 5.1 shows the grade markings, descriptions, grades, parent metal, heat treatment, and tensile strength for the most common SAE bolt hardness grades.

Metric Hardness Grades

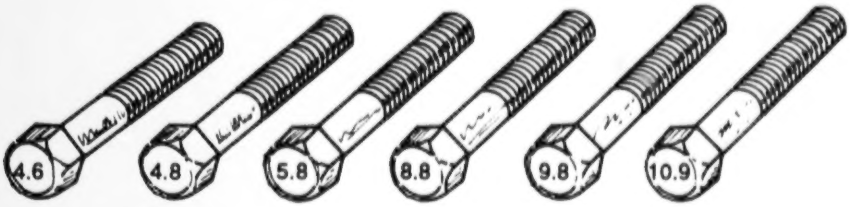
Metric bolts are widely used on agricultural machinery and equipment. The hardness of a metric bolt can be determined by looking at the property class number stamped on the head of the bolt, see Figure 5.1. As the property class number increases, the hardness (tensile strength) of the bolt also increases.

TABLE 5.1 - Non-metric Hardness Grades

SAE GRADE MARKINGS					
DESCRIPTION AND SAE GRADES	No lines – unmarked indeterminate quality SAE Grades 0-1-2	3 lines – common commercial quality Automotive & AN Bolts SAE Grade 6	4 lines – medium commercial quality Automotive & AN Bolts SAE Grade 6	5 lines – rarely used SAE Grade 7	6 lines – best commercial quality N.A.S. & Aircraft Screws SAE Grade 8
MATERIALS	Low-Carbon Steel	Med.-Carbon Steel Tempered	Med.-Carbon Steel Quenched & Tempered	Med.-Carbon Alloy Steel	Med.-Carbon Alloy Steel Quenched & Tempered
TENSILE STRENGTH	65,000 p.s.i.	120,000 p.s.i.	140,000 p.s.i.	140,000 p.s.i.	150,000 p.s.i.

Credit: Reproduced by permission; Motor Automotive Mechanics by Anthony Schwaller, Delmar Publishers Inc., Copyright 1988.

FIGURE 5.1 - Hardness Grade of Metric Bolts



Summary

It is very important to select the correct bolt hardness for each application. Bolts are manufactured in many different degrees of hardness. The hardness of a non-metric bolt can be determined by observing the SAE grade markings found on the head of the bolt. As the number of marks increases, so does the hardness of the bolt. The hardness of a metric bolt can be determined by looking at the property class number stamped on the head of the bolt. The hardness of the bolt increases as the property class number increases. When replacing equipment bolts, it is a good practice to make sure that the grade of the replacement bolt is the same as the grade of the original bolt. If in doubt, consult the operator or repair manual. Remember, selecting the proper bolt for each application can prevent bolt failure and/or expensive equipment damage.

Credits

Schwaller, Anthony E. Motor Automotive Mechanics. Albany, NY: Delmar Publishers, Inc., 1988.

Walker, John R. Modern Metalworking. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

UNIT IV - METALS

Lesson 6: Controlling Heat Distortion

Objective: The student will be able to control heat distortion in metals.

Study Questions

1. **What is distortion?**
2. **When is heat distortion most likely to be a problem?**
3. **How does the amount of weld deposit affect distortion?**
4. **What techniques may be used to remove distortion from a finished project?**

Reference

1. Handout
   a) HO 6.1: Controlling Heat Distortion

UNIT IV - METALS

Lesson 6: Controlling Heat Distortion

TEACHING PROCEDURES

A. Review

Review Lesson 2 of the Arc Welding unit in the Agricultural Science II Core Curriculum on distortion.

B. Motivation

Show the class two pieces of metal that were welded together in which warping occurred. Also provide an example of a single plate in which bowing occurred when welds were placed only on one side of the metal.

C. Assignment

D. Supervised study

E. Discussion

1. The instructor could use the transparency masters from the Agricultural Science II Core Curriculum (Arc Welding, Lesson 2) on the various types of distortion and causes of distortion. Ask the class to define distortion.

   What is distortion?

   a) Expansion and contraction change the physical properties of the metal being welded, causing them to vary from the original plane on which they were before welding.
   b) Natural expansion and contraction of the base metals is somehow restricted, thereby causing the metal to change dimensions.

2. Ask the class to identify situations in which distortion will likely occur. Review from Agricultural Science II Core Curriculum (Arc Welding, Lesson 2) how distortion may be controlled while welding.

   When is heat distortion most likely to be a problem?

   a) Uneven heating of the base metal
   b) Joining of dissimilar metals
   c) Multiple weld passes
   d) Long beads are deposited.
   e) Metal is unrestrained.
   f) Excess filler metal in the weld deposit

3. Many students tend to overfill the crater while welding. Discuss with the class the effects of the weld deposit on distortion.

How does the amount of weld deposit affect distortion?

- a) Shrinkage forces are greater as more metal is placed in a joint. Use a minimum of weld deposit.
- b) Excess weld deposits do not increase strength, only the cost of the weld.
- c) Avoid convex beads.

4. Ask the class how they could repair distortion damage to their projects after welding has already occurred.

What techniques may be used to remove distortion from a finished project?

- a) Shrinkage
- b) Shrink welding
- c) Cut and replace

F. Other activity

Have the class identify distortion problems in projects in the shop.

G. Conclusion

Distortion can cause severe problems in the construction of a project. There are several methods that can be used to control distortion while welding. Also, methods exist to remove distortion from finished shop projects to improve their appearance and usefulness.

H. Competency

Control heat distortion of metals.

I. Answers to Evaluation

1. When natural expansion and contraction are restricted during welding, the weld metal has a tendency to warp, shrink, or twist out of shape.
2. Uneven heating, multiple weld passes, joining of dissimilar metals, excess filler metal in the weld deposit
3. Too much weld metal will cause distortion to be worse.
4. Shrinkage, shrink welding, or cut and replace

Name ____________________

Lesson 6: Controlling Heat Distortion

Date ____________________

EVALUATION

Complete the following short answer questions.

1. What is heat distortion?

2. What are four things that can cause heat distortion?

   a.

   b.

   c.

   d.

3. What affect does excess filler metal have on the strength of the weld?

4. What three techniques can be used to remove distortion?

   a.

   b.

   c.

Metals expand (become larger) when heated and contract (become smaller) when cooled. The amount of expansion and contraction is directly proportional to the temperature and volume of the base metal. During the welding process, the arc heats the metal in the weld area and causes it to expand. When the arc is removed, the base metal begins to cool and contract. When the processes of expansion and contraction are not properly controlled, distortion of the base metals will occur.

Distortion

Distortion results from the uncontrolled expansion and contraction of metal during the welding process. Expansion and contraction change the physical properties of the metal being welded, causing them to vary from the original plane on which they were before welding occurred. When the natural expansion and contraction of the base metal is somehow restricted, distortion will result. Distortion can occur in several forms, the most common being warps and bows.

Heat Distortion as a Problem

There are many situations that may cause distortion to occur. You should try to avoid or reduce distortion during the welding process when possible, especially if the project has parts that must align with each other in order to work. Uneven heating of the base metal will restrict the expansion ability of the metal, causing the metal to distort. When the metal surrounding the weld area cools at a faster rate than the weld, the metal will have a tendency to bow or warp. Distortion will likely occur when joining dissimilar metals if the processes of expansion and contraction are not controlled. Heat should be concentrated during welding on the thicker piece of metal to reduce the amount of distortion. Multiple weld passes should be avoided whenever possible. The fewer the number of passes made, the less distortion will occur. If a long, continuous bead is required, welding can be accomplished by making short, alternating beads if possible to counteract the effects of the other beads. Spaces between the beads can be filled in after the short beads have been made. Metal that is free moving during welding is more likely to distort than if it had been clamped down.

Excess Filler Metal

Using excess filler metal in the weld deposit increases the chance for distortion. Convex (bowing outward) beads should be avoided since they do not add to the strength of the weld. Adding the extra filler metal is more costly in both time and amount of electrodes. Distortion is usually increased when extra filler metal due to the extra heat that is applied and the amount of expansion and contraction that occurs as a result of the extra beads.

Removing Distortion

Even though you take the steps needed to control distortion in your project, some distortion may still occur. There are several methods available for reducing or repairing the distortion that occurred during the welding process. Shrinkage is the first method for removing distortion from a finished project. In the shrinkage process, the distorted metal is alternately heated and cooled to bring the metal back into proper alignment. A hammer or clamp may be needed to assist in aligning the metal again. You should be careful that the metal does not bend around the weld, causing a "wrinkle" in the metal.

The second method is shrink welding. Shrink welding is accomplished by laying a bead or series of beads on the convex side of the distorted metal. The new beads on the back side will cause the metal to distort back into the proper direction so that more perfect alignment may be accomplished. The beads laid on the backside of the metal may need to be ground off if they are unsightly or cause structural problems. Shrink welding will not provide perfect alignment, but it will improve the appearance of the project. A third alternative for removing distortion is to cut out the distorted area and replace it with a properly welded piece. This alternative is more time-consuming and will usually take away from the appearance and strength of the project.

Summary

Steps should be taken to avoid distortion while welding. If distortion does occur, there are several methods of reducing the effects of the distortion on the finished project. Even though these methods may not completely repair the damage to the project, they will lessen the effects.

Credits

"Agricultural Mechanics Unit", Agricultural Science II Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

Jefferson, T. B., and Gorham Woods. Metals and How to Weld Them. Cleveland: The James F. Lincoln Arc Welding Foundation, 1983.

Morford, V. J., Thomas A. Hoerner, Willard R. Anderson. Metals and Welding. St. Paul: Hobar Publications, 1970.

Lesson 7: Assembling Work Using Proper Locks and Fasteners

Objective: The student will be able to correctly use locks and fasteners in metal projects.

Study Questions

1. **What is torque?**
2. **When should nuts and bolts be torqued?**
3. **How is a torque wrench used?**
4. **What are the steps in torquing a nut or bolt?**

Reference

1. Handout
    a) HO 7.1: Torquing a Nut or Bolt

Lesson 7: Assembling Work Using Proper Locks and Fasteners

TEACHING PROCEDURES

A. Review

Review Lesson 4 of this unit on metal fasteners.

B. Motivation

Have a piece of metal in the classroom that has two tapped holes. Have on hand two bolts that match the tapped holes. Ask a student to tighten the bolts to the same "tightness." Introduce the importance of a torque wrench when tightening bolts to a standard or uniform torque.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss with students the meaning of the term "torque," and its importance when working with metal.

   What is torque?

   a) The amount of twisting force applied to a nut or bolt
   b) The turning effort that causes a nut or bolt to tighten
   c) Force x Distance (length of lever)

2. Not all nuts and bolts will need to be torqued. Ask the class to identify situations when torque would be important for a nut or bolt?

   When should nuts and bolts be torqued?

   a) When nuts and bolts need to be tightened to a uniform amount
   b) To avoid over-tightening of bolt
   c) Prevent warping or misshaping the metal parts

3. The torque wrench must be used properly in order to obtain an accurate reading. Explain to the class the basic principles listed below in using a torque wrench.

   How is a torque wrench used?

   a) Torque is preset with the scale on the wrench handle.
   b) The handle may be pushed or pulled to tighten the nut.
   c) The threads should be clean to prevent a drag on the wrench, resulting in inaccurate torque.
   d) A socket is fitted on to the end of the wrench to tighten the bolt.
   e) Many wrenches will click or release when the correct torque is achieved.

   NOTE: There are other styles of torque wrenches (e.g., wand, direct reading).

4. In order to achieve the correct torque on a nut or bolt, the proper procedure should be followed. Go through the following steps with students for correctly torquing a nut or bolt.

   What are the steps in torquing a nut or bolt?

   a) Determine the type of bolt to be torqued.
   b) Determine the correct torque specification for the nut or bolt to be torqued.
   c) Determine the correct torquing procedure for the application.
   d) Set the correct wrench setting.
   e) Select the correct socket for the bolt to be torqued.
   f) Turn the torque wrench until the desired torque is achieved.

F. Other activities

1. Have students practice using the torque wrench on various nuts and bolts around the shop area.

2. Have students check equipment and automotive manuals to find torque specifications.

G. Conclusion

There are times when the amount of torque on a bolt will determine the accuracy and durability of a project. When several bolts need to be uniformly tightened, a torque wrench should be used to eliminate the guesswork.

H. Competency

Assemble work using proper locks and fasteners.

I. Answers to Evaluation

1. A turning effort that causes a nut or bolt to tighten. The tendency of a force to twist a body about an axis of rotation.
2. 1) Determine the type of bolt to be torqued, 2) Determine the correct torque specification, 3) Set the correct wrench setting, 4) Select the correct socket, 5) Torque the bolt.
3. Torque is preset on the wrench, the handle may be pushed or pulled to tighten the bolt, clean threads on the bolt for an accurate reading, a socket is fitted to the end of the wrench.
4. When bolt should be tightened uniformly, when a bolt should be tightened to a specified torque.

Name ____________________

Lesson 7: Assembling Work Using Proper Locks and Fasteners

Date ____________________

EVALUATION

Complete the following short answer questions.

1. What is torque?

2. What are the steps in torquing a bolt?
   a.
   b.
   c.
   d.
   e.

3. How is a torque wrench operated?

4. What are two reasons for torquing nuts and bolts?
   a.
   b.

Torque

Torque is the amount of twisting force applied to a bolt or nut. It is the turning effort that causes a nut or bolt to tighten. Torque is equal to Force x Distance (length of the handle).

Torquing Nuts and Bolts

Torquing should be done when several nuts and bolts need to be tightened to a uniform torque or a bolt is needed for maximum holding power. You should torque a bolt or nut to avoid over-tightening which can result in stripping the threads or breaking the bolt. Warping or misshaping the metal parts can also be a result of over-tightening of the bolt.

Using a Torque Wrench

Torque is measured in foot-pounds and is preset with the scale on the wrench handle. A torque wrench should be used to obtain the correct amount of torque on each nut and bolt to ensure uniformity or tightened to a preset standard. The handle of the torque wrench may be pushed or pulled to tighten the nut, though pulling is the preferred method. Never lengthen the handle of a torque wrench since it will cause inaccuracy on the reading. The threads of the nut and bolt should be clean to prevent a drag on the wrench, which results in an inaccurate torque. A socket is fitted on to the end of the wrench to tighten the bolt. When the preset torque is reached, the wrench will click or release, depending on the type of wrench you are using. There are several other types of torque wrenches (e.g., wand, direct reading).

Torquing a Nut or Bolt

The correct procedure should be followed to achieve the desired torque. Each type of bolt requires a different torque. You should first determine the grade of bolt you are using by the markings on the head of the bolt. Once the grade is determined, you should refer to the torque specification table for the correct torque for a particular bolt. Determine the correct torquing procedure for the application. The correct setting should be set on the scale on the wrench. Choose the appropriate socket to match the bolt head and attach the socket to the torque wrench. Tighten the bolt with the torque wrench until the proper torque is reached. Table 7.1 lists the required torque for common SAE grade bolts. If several bolts attach an item, look for a torquing sequence and then torque the component according to the manufacture's recommendations.

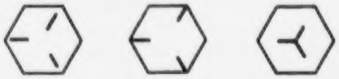
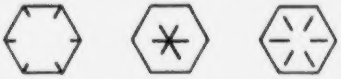
Credits

Bear, W. Forrest; Thomas A. Hoerner. Torque and Torque Wrenches (Bulletin 171). St. Paul, MN: Hobar Publications, 1984.

TABLE 7.1 - Torque Specifications

TORQUE SPECIFICATION TABLE

1. Use the following torques when special torques are not given
2. DRY TORQUE. No additional lubricant added to threads.
3. LUBRICATED TORQUE.

SAE Grade No.	5		8	
Bolt head identification marks as per grade Note: Manufacturing Marks Will Vary				
	Torque Pound Feet	Torque Pound Feet	Torque Pound Feet	Torque Pound Feet
Bolt Size	Dry	Lubricated	Dry	Lubricated
1/4"	8-10	6-7	12-14	9-10
5/16	17-19	13-14	24-26	18-20
3/8	30-35	23-25	45-50	34-36
7/16	50-55	35-40	70-80	55-60
1/2	75-90	55-65	110-120	80-90
9/16	110-120	80-90	150-170	110-130
5/8	150-180	110-130	220-240	170-180
3/4	260-300	200-220	380-420	280-320
7/8	400-440	300-320	600-660	460-500
1"	580-640	440-480	900-1000	680-740
1-1/8	800-880	600-660	1280-1440	960-1080
1-1/4	1120-1240	840-920	1820-2000	1360-1500
1-3/8	1460-1680	1100-1260	2380-2720	1780-2040
1-1/2	1940-2200	1460-1640	3160-3560	2360-2660

Credit: Used with permission; Torque and Torque Wrenches. St. Paul, MN: Hobar Publications, 1984.

Lesson 8: Using Heat to Shape Metal

Objective: The student will be able to identify the methods of bending metal using heat.

Study Questions

1. **How does heat affect metal?**
2. **What is the critical temperature of a metal?**
3. **What methods of shaping metal use heat?**
4. **Compare bending cold metal to bending heated metal.**
5. **Which metals are suitable for bending?**

Reference

1. Handout
    - a) HO 8.1: Shaping Metal with Heat

Lesson 8: Using Heat to Shape Metal

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Secure a piece of mild steel in a vise and have a student bend an angle in the metal, using a hammer. Using the oxy-acetylene torch, heat a different piece of metal until it is cherry red. Have another student bend the hot metal with a hammer to show how easily it is bent when heat is applied, compared to when it is cold.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the changes that take place in the structure of a metal when heat is applied.

   How does heat affect metal?

   a) Heat causes a restructure of grain particles in the metal to form a finer grain structure. When the metal is bent, the grain will follow the bend.
   b) Heat improves most properties of the metal.
   c) Heat removes some internal defects, such as porosity, gas pockets, and internal stress.

2. Ask students to define critical temperature in relation to metal.

   What is the critical temperature of a metal?

   a) When metal changes from one type of structure to another as a result of heating or cooling
   b) Also known as the transformation temperature
   c) The farther above the critical temperature that the metal heats, the more coarse the grain becomes

3. Several methods may be used to heat metal for shaping. Ask the class to list the methods that are available in the shop.

   What methods of shaping metal use heat?

   a) Forge
   b) Carbon-Arc torch
   c) Oxy-acetylene
   d) Furnaces

4. Heat is not always required to bend metal. Ask the class to list situations when heat should be used.

   Compare bending cold metal to bending heated metal.

   a) Cold bending
      1) Metal greater than 1/2" square, 1/2" round, or 3/16" x 1" wide is difficult to bend cold.
      2) Special equipment may be needed for some types of bends (e.g., curves).
      3) Increases stresses on the metal.
      4) Cold bending creates better surface finishes.
      5) Less safety hazards exist since heat and fire are not used.
      6) Since cold bending does not restructure the metal, the metal may be weakened.

   b) Hot bending
      1) Larger sizes of metal may be bent.
      2) Most shops will have equipment needed.
      3) Less stress on metal because of restructuring of metal grains from heating and cooling.
      4) Heat bending improves the mechanical properties of the metal.
      5) Heat bending increases safety hazards.

5. Discuss the types of metals that can be bent. Discuss the meaning of ductility in a metal. Explain why some metals are not suitable for bending.

   Which metals are suitable for bending?

   a) Aluminum
   b) Brass
   c) Copper
   d) Lead
   e) Magnesium
   f) Mild steel
   g) Silver
   h) Stainless steel
   i) Wrought iron
   j) Zinc

F. Other activities

1. Show the class equipment available in the shop for bending metal.

2. Plan a field trip to a local industry that fabricates products out of metal to illustrate how they shape the metal used for their products.

3. Provide a demonstration of the methods used to bend various types and thicknesses of metal.

G. Conclusion

Metals may be bent using heat. Heat changes the structure of metal and makes it easier to bend. Often, the metal characteristics will improve because of the change in structure. A variety of tools and equipment is used in order to shape metals.

H. Competency

Use heat to shape metals.

I. Answers to Evaluation

1. Two of the following: restructure of grain particles, improve characteristics of the metal, removes internal defects
2. When a metal changes from one type of structure to another
3. Forge, oxy-acetylene, carbon-arc torch, furnaces
4. Two of the following: larger sizes may be bent, most shops have the equipment, less stress on the metal, improve characteristics of the metal
5. Better surface finish, less safety hazard
6. Four of the following: aluminum, brass, copper, lead, magnesium, mild steel, silver, stainless steel, wrought iron, zinc

UNIT IV - METAL

Name _______________

Lesson 8: Using Heat to Shape Metal

Date _______________

EVALUATION

Complete the following short answer questions.

1. List two ways that heating can affect the characteristics of metal.

   a.

   b.

2. What is "critical temperature?"

3. What are four pieces of equipment that can be used to heat metal for bending?

   a.

   b.

   c.

   d.

4. What are two advantages of using heat to bend metal?

   a.

   b.

5. What are two advantages of bending the metal cold?

   a.

   b.

6. What are four types of metal that are suitable for bending?

   a.

   b.

   c.

   d.

Agricultural workers must occasionally bend or shape metal in order to repair or construct agricultural equipment. Small pieces of metal can often be shaped cold; however, large pieces of metal must usually be heated before they can be easily and accurately shaped.

Mild steel melts at approximately 2700°F. Iron and steel should be heated to a dark-red color (approximately 1200°F) before they are bent or shaped. Metal worked at less than a dark-red color may crack. Metal which is heated until it sparks has been overheated and may lose many of its desirable characteristics.

The Effect of Heat on Metal

The heating process will cause several changes in the metal. The grain structure of the metal will change to form a finer, closer structure than the metal originally had. When the metal is bent, the grain particles follow the bend, thus making the metal stronger than if the metal would have been cut or machined. Many of the properties of the metal, such as strength, will be improved as a result of heat. Many of the internal defects, such as porosity, gas pockets, and internal stresses will be lessened or eliminated.

Critical Temperature

When a metal changes from one type of structure to another, it has reached its critical (transformation) temperature. The farther above the critical temperature (toward melting) that the metal is heated to, the more coarse the grain becomes, thus making it harder to work. When heating metal to bend, you should heat it as close to the critical temperature as possible to achieve the best results.

Sources of Heat

There are several sources of heat that are available in most agricultural education shops that will heat metal enough to bend.

Forge - Many shops are equipped with forges. With a forge, the metal is placed in the heat until it becomes red and then removed and worked. Blacksmiths use forges to shape horseshoes to fit the individual hooves of the horse. An anvil and a hammer are generally used to work the metal once it reaches the critical temperature.

Carbon-Arc Torch - The carbon-arc torch, which can be used with either an A.C. or D.C. welding machine, is also an excellent heat source for shaping metal. The carbon-arc torch produces a flame-type heat when an arc is struck between the two carbon electrodes. Heating with a carbon-arc torch can be a continuous process. Therefore, caution should be exercised to avoid exceeding the duty cycle capacity of the welding machine.

Oxy-Acetylene - Oxy-acetylene is a good source of heat, though it is difficult to heat a very large area of metal at one time. An anvil or a vise can be used to hold the metal after it has been heated and a hammer can be used to bend the metal around the anvil horn or vise jaws. When using a vise to bend metal, the point where the bend is to occur should be slightly above the jaws of the vise to allow for the bend.

Furnaces - A variety of furnaces is available for use in heating metal for bending. These furnaces may be fueled by gas, electricity, or oil. Furnaces are useful if the metal to be bent is small enough to fit in the furnace. Large pieces of metal do not work well.

Cold Bending versus Hot Bending

Larger pieces of metal require heat to produce a good bend. The mechanical properties of metal are improved during heating due to the resulting finer structure of the grain particles. Not all metal will require the use of heat to bend. Metals that are less than 1/2" square, 1/2" round, or 3/16" x 1" wide can usually be bent without the use of heat. There are several advantages to bending cold metal. Better surface finishes can be achieved when heat is not used since the oxides formed from the reaction of the metal to the heat are not present. Fewer safety hazards will exist if heat is not used since heat and fire are not present. There are also several disadvantages to bending cold metal. Cold bending will increase the internal stress on metal and heating later may be needed to relieve the internal stresses. Special equipment may be needed to produce the desired cold bends, however most shops will have adequate equipment to produce almost any type of bend using heat. Cold bending will not allow for a restructuring of the grain particles and may actually weaken the metal.

Metals That May Be Bent

While you might possibly be able to bend any type of metal, not all metals are suitable for bending since they may be weakened as a result of the bending. The following metals are considered suitable for bending: aluminum, brass, copper, lead, magnesium, mild steel, silver, stainless steel, wrought iron, and zinc.

Summary

Metals may be bent with or without heat. Several considerations should be made when deciding which method to use. The size of the metal, desired surface finish, and available equipment should all be considered when choosing the most appropriate method.

Credits

Morford, V. J.; Thomas A. Hoerner; Willard R. Anderson. Metals and Welding. St. Paul: Hobar Publications, 1970.

Morrisey, Thomas J. Introductory Metalworking. Cincinnati, OH: South-Western Publishing Co., 1983.

Walker, John R. Modern Metalworking. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

Lesson 9: Hand and Machine Threading

Objective: The student will be able to hand and machine thread metal pieces.

Study Questions

1. **What tools are needed to cut threads by hand?**
2. **How are taps and dies sized?**
3. **What is a screw pitch gauge?**
4. **How is a hole tapped by hand?**
5. **How are external threads cut with a die?**
6. **How can the drill press be used for tapping?**
7. **How is pipe threaded?**

References

1. Handout
   - a) HO 9.1: Hand and Machine Threading
2. Demonstration Sheets
   - a) DS 9.1: Cutting Internal Threads With a Tap
   - b) DS 9.2: Cutting External Threads With a Die
   - c) DS 9.3: Using the Drill Press as a Precision Guide for Tapping
   - d) DS 9.4: Tapping a Hole With a Drill Press
   - e) DS 9.5: Cutting Pipe Threads
3. Job Sheets
   - a) JS 9.1: Cutting Internal Threads With a Tap
   - b) JS 9.2: Cutting External Threads With a Die
   - c) JS 9.3: Using the Drill Press as a Precision Guide for Tapping
   - d) JS 9.4: Tapping a Hole With a Drill Press
   - e) JS 9.5: Cutting Pipe Threads

UNIT IV - METALS

Lesson 9: Hand and Machine Threading

TEACHING PROCEDURES

A. Review

Review Lesson 1 of the Cold Metal Working unit in the Agricultural Science II Core Curriculum. Since tapping by hand was covered in the Agricultural Science II, methods of machine tapping and threading will be discussed in this lesson.

B. Motivation

Have students locate things in the shop that require the use of a tap and die set. Award a prize to the student (or group) that locates the most items.

C. Assignment

D. Supervised study

E. Discussion

1. Have the tools listed below on display for the class to identify. Show how the tools work together to cut threads in metal.

   What tools are needed to cut threads by hand?

   a) Taps
      1) Taper
      2) Plug
      3) Bottoming
   b) Tap wrenches
   c) Dies
      1) Solid
      2) Split or adjustable
         a. Solid split
         b. Two-piece split
   d) Die stock

2. Pass the above tools around for the class to identify the size by the markings on the tools.

   How are taps and dies sized?

   a) Based on diameter and pitch
   b) Stamped on tap or die
   c) Type of threads
      1) National coarse
      2) National fine
      3) Metric

3. Demonstrate to the class how to use a screw pitch gauge. Have several students determine the number of threads per inch.

   What is a screw pitch gauge?

   a) Determines the pitch of a threaded object
   b) Made up of thin blades with teeth

4. Use DS 9.1 to illustrate the proper way to tap a hole using a tap and die set. JS 9.1 should be completed by the student. Assign JS 9.1.

   How is a hole tapped by hand?

   a) Always wear safety glasses (ANSI Z87.1) when threading.
   b) Drill the proper size hole (drill size = tap diameter - 1 / pitch)
   c) Select the correct size tap, tap wrench, and threading lubricant.
   d) Turn the tap in a two turns in a clockwise direction, backing up 1/2 turn to remove chips.
   e) Check for squareness of the tap.

5. Use DS 9.2 to illustrate the proper way to cut external threads using a die and die stock. Assign JS 9.2.

   How are external threads cut with a die?

   a) Always wear safety glasses (ANSI Z87.1) when threading.
   b) Bevel the end of the rod.
   c) Select the proper die and threading lubricant.
   d) Insert the die on the end of the rod and turn in clockwise direction.

6. Use DS 9.3 and DS 9.4 to illustrate the proper way to use a drill press for tapping a hole. Assign JS 9.3 and JS 9.4.

   How can the drill press be used for tapping?

   a) Always wear safety glasses (ANSI Z87.1) when threading.
   b) Used as a precision guide for manual tapping
   c) Tapping attachment

7. Use DS 9.5 to illustrate the proper way to thread a pipe. JS 9.5 should be completed by the student.

   How is pipe threaded?

   a) Always wear safety glasses (ANSI Z87.1) when threading.
   b) Cut a piece of pipe to the desired size.
   c) Secure the pipe in a pipe vise.
   d) Ream the burrs in the inside of the pipe.
   e) Select the proper die and threading lubricant.
   f) Insert the die on the end of the pipe and turn in a clockwise direction.

F. Other activity

Visit a local manufacturing plant to observe tap and die applications.

G. Conclusion

In many agricultural repair situations, you may need to cut threads. A tap and die set, a drill press, and a pipe threader may be used to cut new threads in metal.

H. Competency

Use a tap and die set to do threading.

I. Answers to Evaluation

1. c
2. a
3. e
4. f
5. g
6. d
7. b
8. h
9. d
10. c

UNIT IV - METALS Name ____________________

Lesson 9: Hand and Machine Threading Date ____________________

EVALUATION

Match the following tools with the correct picture by placing the letter of the picture in front of the correct tool name.

_____ 1. Die

_____ 2. Pipe reamer

_____ 3. Tap wrench

_____ 4. Die stock

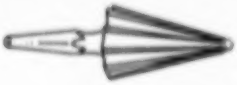
_____ 5. Pipe cutter

_____ 6. Tap

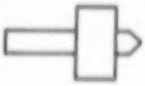
_____ 7. Lathe center

_____ 8. Pipe vise

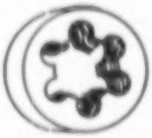
a.



b.



c.



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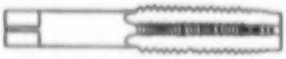

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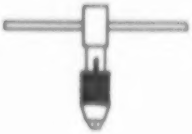
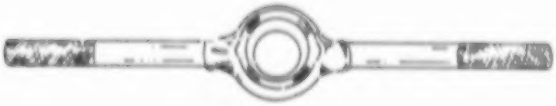
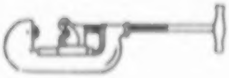


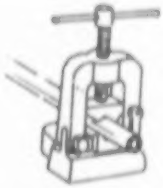
f.



g.



h.



Circle the letter that corresponds to the best answer.

9. A screw pitch gauge measures _______________.

   a. Number of threads on the screw
   b. Diameter of the hole
   c. Diameter of the tap
   d. Number of threads per inch
   e. Length of the screw

10. Which of the following is used to cut threads on the inside of the hole?

   a. Pipe reamer
   b. Die
   c. Tap
   d. Screw pitch gauge
   e. Tap wrench

Agricultural workers must occasionally thread metal pieces prior to joining them together. Skilled workers are able to make threads as good as those on commercially threaded products. The tools, equipment, and procedures for cutting threads, both by hand and machine, are discussed below.

Cutting Threads by Hand

The tools necessary for cutting threads by hand are taps, tap wrenches, dies, and die stocks. A complete set of these tools is called a screw plate. Taps are hardened steel tools used to cut internal threads in drilled holes. The parts of a tap are illustrated in Figure 9.1.

FIGURE 9.1 - Parts of a Tap

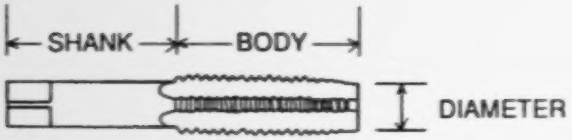
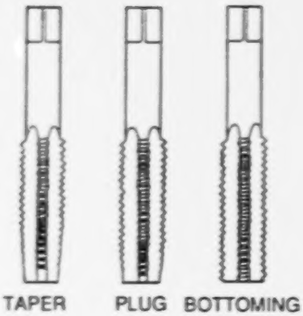


FIGURE 9.2 - Types of Taps

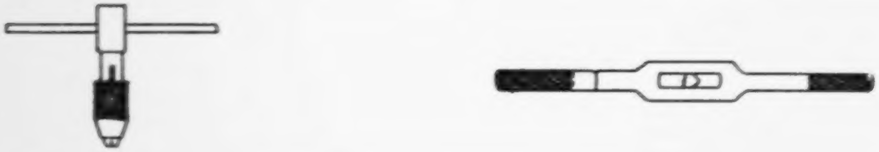


Three types of taps are available: taper, plug, and bottoming. These taps are used in the order shown in Figure 9.2 to thread a "blind" hole (one that does not go entirely through the metal). The first six threads on a taper tap are not full diameter threads. This makes the taper tap easy to start so it is used to begin tapping a blind hole. The taper tap is used alone when tapping a hole that goes all of the way through the piece of metal.

The plug tap has three to four partial threads. A plug tap is used to follow the taper tap when threading a blind hole. The bottoming tap has only one partial thread. It is used after the plug tap when a blind hole must be threaded all of the way to the bottom.

When threading holes with a tap, the tap is turned by using a tap wrench. A tap wrench is similar in operation to the chuck on a drill press. The end of the tap is inserted into the jaws of the tap wrench and tightened to prevent slipping during operation. A handle is provided on top to allow even pressure to be applied when turning the tap. There are several styles of tap wrenches, two of which are illustrated in Figure 9.3.

FIGURE 9.3 - Tap Wrenches



Dies are hardened steel tools that are used to cut external threads on metal rods. Dies have tapered teeth which cut progressively fuller threads until full thread depth is reached. Two types of dies are commonly available. Solid dies are generally used for small work. Since solid dies must cut full threads in one pass of the die, they require more power to operate. Split dies, also known as adjustable dies, can be adjusted to a limited degree by turning a small setscrew in the die. There are two types of split dies: solid split and two-piece split. This adjustment allows the worker to cut threads in successive passes of the die by tightening the setscrew prior to each pass. Since threads can be cut gradually to full size, this die is relatively easy to operate, thus making split dies especially useful for threading large diameter rods.

FIGURE 9.4 - Solid Die

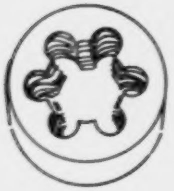
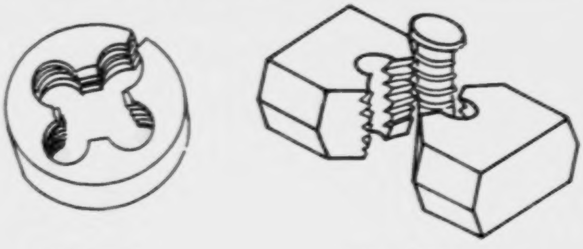


FIGURE 9.5 - Split Dies

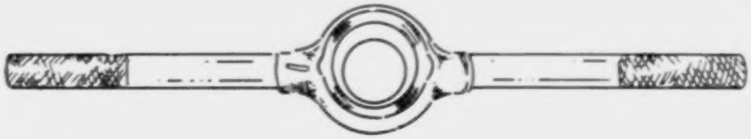


Solid split

Two-piece split

A die stock is used to turn the die to cut threads. The die is inserted into the die stock and the setscrew is tightened to prevent the die from slipping during cutting. One hand grasps each handle of the die stock and turns in a clockwise direction, making sure that even pressure is exerted on each handle.

FIGURE 9.6 - Die stock



Tap and Die Sizes

The size of a tap or die is based on the diameter and pitch (number of threads per inch) of the threads that it will cut. This information is stamped on each tap or die. For example, a tap stamped NC 1/2-13 will cut 1/2" National Coarse threads having 13 threads per inch. A 1/2" rod threaded with a NC 1/2"-13 die will mate perfectly in the tapped hole. The NC in the marking stands for National Coarse threads. If NF appears in the marking this refers to National Fine threads. A hole threaded with a NC tap will not accept a rod threaded with a NF die.

Screw Pitch Gauge

A screw pitch gauge can be used to determine the pitch (number of threads per inch) of a threaded object. The gauge contains several thin blades which each have a different number of saw-like teeth. The number of teeth per inch is stamped on each blade. The pitch of any threaded object can be determined by trying the different blades until one is found that perfectly fits the threads in question. The number of threads per inch can then be read directly off the blade.

Cutting Threads by Hand

Tapping - Before you can tap a hole, you must drill the proper sized hole for the tap being used. Information for the proper size hole to drill is stamped on each tap. The correct size of hole to drill can also be determine by using the following formula:

Tap diameter - 1 + pitch = Drill size

For example, to determine the size of hole to drill prior to tapping with a NF 1/2"-16 tap would be determined as 1/2" - 1/16 = 7/16". Therefore, a 7/16-inch hole would be drilled. You can also refer to: 1) information on the tap and 2) the box housing the taps and dies to determine the size of hole to drill.

A tap wrench is used to turn the tap as it cuts threads in the hole. The tap wrench has handles on each side so that an equal amount of torque may be applied on both sides of the tap. Visually check to make certain that the tap is straight with the hole. Then apply threading lubricant. Downward pressure is applied to the tap wrench while turning it in a clockwise direction. Once the tap has begun to feed itself, you should carefully remove the tap wrench and use a try square or combination square to make certain that the tap is started in the hole squarely. If the tap is not started squarely, it should be backed out and re-started. Do not try to square the tap by applying pressure to the tap wrench since taps are brittle and easily broken. A threading lubricant is used when tapping holes to make the tap cut easier and to float out metal chips from the threads. Turn the tap clockwise one to two turns and then counter-clockwise for 1/2 turn. This counter-clockwise rotation will allow the tap to break the metal chips and will result in smoother threads.

Cutting External Threads with a Die - A die and die stock may be used to cut external threads on rods that are to be inserted into a tapped hole. When choosing the rods to cut threads, cold rolled mild steel will work much better than hot rolled mild steel. Before cutting the threads, you should use a metal file to bevel the end of the rod to allow the die to be started more easily. When choosing a die, you should select one with the same diameter of the rod and the desired number of threads per inch. The tapered end of the die should be inserted on the beveled end of the rod and turned in a clockwise direction. As in tapping a hole, lubricant is needed to allow easier cutting by the die.

Drill Press for Tapping

Manual Tapping with a drill press - A drill press can be used as a precision guide to manually tap a hole. Once the correct size of hole has been drilled for tapping, the drill press can be used as a precision guide for manual tapping. In order to use the drill press for manual tapping, a lathe center from a metal lathe is inserted into the chuck of the drill press. The electricity should be disconnected to the drill press since it is being used only as a guide. Without a special attachment, you cannot use power from the drill press to tap the hole. The drill press will turn the tap at too high of a speed which will shatter the tap and possibly cause injury. The lathe center is lowered into the center hole of the tap and slight pressure is applied to the tap. While this pressure is being applied, the tap by hand is turned to cut the threads.

Power tapping with the drill press - Internal threads can be cut using the drill press as a power source. However, a tapping attachment must be used with the drill press in order to prevent tap breakage and operator injury. Most tapping attachments have a mechanism to control the tap feed rate and the amount of torque applied to the tap. Most tapping attachments also have a reversing device which automatically backs the tap out of the hole when downward pressure is released. The operating instructions which are furnished with the tapping attachment must be followed to prevent equipment damage or personal injury.

Threading Pipe

Agricultural workers are frequently required to thread pipes. This ability is often necessary when making plumbing or hydraulic equipment repairs. Most pipe is threaded with American Standard Taper Pipe Thread (NPT). These threads are tapered 3/4" per foot of thread length so that when the fittings are attached an air tight and liquid tight joint is formed.

The following equipment is needed to thread pipe:

Pipe vise - A pipe vise will allow the pipe to be laid flat on the table while work is being done. It has special "v-shaped" jaws that clamp solidly against the pipe to hold it in place. (See Figure 9.7.)

FIGURE 9.7 - Pipe vise

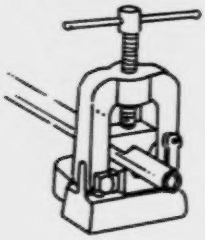
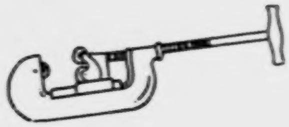


FIGURE 9.8 - Pipe cutter



Pipe cutter - A pipe cutter (Figure 9.8) is used to cut pipe that may be difficult to move to an abrasive cut-off saw. Wheels on the pipe cutter cut a groove on the pipe as the cutter is turned around the pipe. The handle on the end is tightened each rotation to cut deeper into the pipe until a complete cut is made.

Pipe reamer - When pipe is cut, burrs are usually left on the inside lip of the pipe. The reamer is used to remove these burrs to return the pipe to its original diameter.

FIGURE 9.9 - Pipe reamer

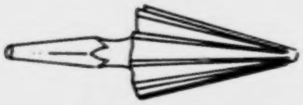
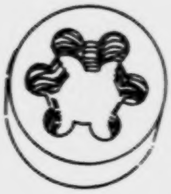


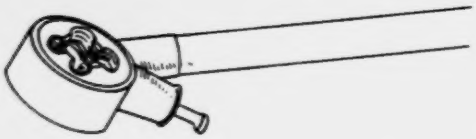
FIGURE 9.10 - Die



Die - Dies used to cut pipe are similar to those used for rods, except they are bigger. The dies cuts threads much like a rod die.

Die stock - The die stock for pipe dies has one handle that is much longer than a regular die stock to provide added leverage to turn the larger dies.

FIGURE 9.11 - Die stock



Summary

Both machine and hand methods of tapping holes may be used. Proper procedures and equipment should be used to provide a quality job. It is important to know the proper equipment to use and safety procedures to follow when tapping and threading.

Credits

"Agricultural Mechanics - Cold Metal Unit", Agricultural Science II Core Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

Morrisey, Thomas J. Introductory Metalworking. Cincinnati, OH: South-Western Publishing Co., 1983.

Walker, John R. Modern Metalworking. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

Demonstration Sheet 9.1: Cutting Internal Threads With a Tap

Objective: At the completion of this demonstration, the student will be ready to tap internal threads in a piece of metal.

Tools and Equipment Needed:

1. Drill press
2. Tap
3. Tap wrench
4. Try square
5. Safety glasses*

*CAUTION: Safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of metal
2. Threading lubricant

Procedure:

1. Using the drill press, drill the proper sized hole for tapping. The proper sized hole can be determined by this formula: Tap diameter - 1 + pitch.

2. Select the proper tap and insert the square end in the tap wrench. The size is stamped on the tap. Make sure that the tap is secured tightly in the tap wrench.

3. Lubricate the tap and workpiece with the proper lubricant.

4. Hold the tap wrench with the hand directly over the tap. Place the tapered end of the tap in the drilled hole.

5. Check to make certain that the tap is straight with the hole.

6. Apply downward pressure on the tap wrench while turning it in a clockwise direction. Turn the wrench two full turns.

7. Remove the tap wrench from the tap and use a try square or a combination square to make sure the tap is straight.

8. Carefully place the tap wrench back on the tap so that the tap is not knocked out of alignment.

9. Apply proper lubricant as necessary. Threading lubricant should be used to aid the tap in cutting and to remove chips from the threads.

10. Place one hand on each end of the tap wrench.

11. Turn the tap clockwise for one to two turns and then counter-clockwise for 1/2 turn. The counter-clockwise motion will release the cut metal from the threads.

12. Continue threading until the tap reaches the bottom of the blind hole or turns free after coming through the bottom of the hole drilled completely through the metal.

13. Remove lubricant and chips from the tap and tap wrench. Return them to the appropriate storage place.

14. Screw a correct sized bolt into the tapped hole to check for accuracy.

15. Ask students if they have any questions. Repeat the above steps if necessary.

16. Assign JS 9.1.

Demonstration Sheet 9.2: Cutting External Threads with a Die

Objective: At the completion of this demonstration, the student will be ready to use a die to thread a rod.

Tools and Equipment Needed:

1. File
2. Die
3. Die stock
4. Safety glasses*

*CAUTION: Safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Threading lubricant
2. Piece of rod

Procedure:

1. Clamp the rod to be threaded in a vise. Make sure that the rod is straight.

2. Use a file to bevel the end of the rod. Beveling the end will allow the die to start easier and straighter.

3. Select a die the same size as the diameter of the rod and with the desired number of threads per inch. The size should be stamped on the die.

4. Insert the die in the die stock. Make sure the die is tightly secured.

5. Lubricate the tap and rod with the proper lubricant.

6. Place the die over the rod with the tapered side toward the rod. If the die is used the other direction, the joint will tend to be less air and water tight because the threads will not be tapered.

7. Start the die by turning it in a clockwise direction while applying downward pressure. Make certain that the die starts squarely.

8. Once the die begins to feed itself, apply the correct lubricant to the die and rod.

   NOTE: A split die or a two-piece split die can be adjusted to cut shallower or deeper. Check the thread depth with a new nut of the appropriate size. If the threads are too shallow, the nut will turn hard. If the threads are too deep, the nut will wobble. Adjust your die appropriately to achieve the desired thread depth.

9. Continue threading the rod by turning the handle clockwise until the desired length of rod has been threaded.

10. Remove the die and die stock from the rod. Remove lubricant and metal chips from them before returning them to the appropriate storage area.

11. Ask the class if they have any questions. Repeat the above steps if necessary.

12. Assign JS 9.2.

Demonstration Sheet 9.3: Using the Drill Press as a Precision Guide for Tapping

Objective: At the completion of this demonstration, the student will be ready to tap threads in a piece of metal using the drill press as a precision guide.

Tools and Equipment Needed:

1. Drill Press
2. Chuck key
3. Lathe center
4. Tap
5. Tap wrench
6. Safety glasses*

*CAUTION: Safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of metal
2. Threading lubricant

Procedure:

1. Select a piece of metal in which to drill and tap a hole.

2. Using the drill press, drill the correct size hole for the tap to be used. The size of hole to drill can be determined by the following formula: Tap diameter - 1 + pitch.

CAUTION: After the hole is drilled, disconnect the drill press from the power source to avoid accidental starting while tapping. For tapping, the drill press is used only as a precision guide, not as a power tool.

3. Remove the drill bit from the chuck of the drill press.

4. Insert and tighten a metal lathe center in the chuck of the drill press.

5. Place the tap wrench on the tap. Make sure it is tight before using.

6. Align the tap with the hole in the metal.

7. Turn the pilot wheel of the drill press so that the lathe center is placed in the center hole in the shank end of the tap.

8. Lubricate the tap and workpiece with the proper lubricant.

9. Turn the tap handle by hand while, at the same time, applying slight pressure with the pilot wheel of the drill press.

10. Continue in this manner until the threads are tapped to a sufficient depth. Depth may be preset using the depth stop on the drill press.

11. Clean the tools and return them to the appropriate storage area.

12. Check the hole for accuracy.

13. Ask the class if they have any questions. Repeat the above steps if necessary.

14. Assign JS 9.3.

Demonstration Sheet 9.4: Tapping a Hole With a Drill Press

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on tapping a hole using the tapping attachment on the drill press.

Tools and Equipment Needed:

1. Drill press
2. Drill bit
3. Chuck key
4. Tapping attachment
5. Tap
6. Clamp
7. Safety glasses*

*CAUTION: Safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Threading lubricant
2. Piece of metal

Procedure:

CAUTION: Never try to tap a hole without using the tapping attachment. The speed of the drill press will shatter the tap and possible cause injury to the operator.

1. Select a piece of metal to work and clamp it to the table.
2. Using the drill press, drill the correct sized hole for the tap to be used.
3. Connect the tapping attachment to the drill press according to manufacturer's directions.
4. Insert the appropriate tap into the tapping attachment.
5. Align the metal on the table with the tap. Clamp it in place.
6. Preset the depth of the hole with the depth stop on the side of the drill press.
7. Lubricate the tap and workpiece with the proper lubricant.
8. Turn the drill press on and lower the tap into the hole using the pilot wheel of the drill press. Apply lubricant as necessary.
9. When the tap reaches the predetermined depth, the attachment will stop the tap from turning.
10. Raise the pilot wheel to back the tap out of the hole.
11. Clean the lubricant and metal chips from the metal and the drill press.

12. Check the hole for accuracy.

13. Assign JS 9.4.

Demonstration Sheet 9.5: Cutting Pipe Threads

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet on cutting threads on a pipe.

Tools and Equipment Needed:

1. Pipe vise
2. Pipe cutter
3. Pipe reamer
4. Die
5. Die stock
6. Collet
7. Safety glasses*

*CAUTION: Safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Pipe
2. Threading lubricant

Procedure:

1. Secure the pipe in a pipe vise.

2. Cut the pipe to the required length using a pipe cutter.

3. Ream the inside of the pipe using a pipe reamer. Bevel the outside edge of the pipe using the same technique as for beveling a rod.

4. Select the proper size of collet (guide) and die, and insert them in the die stock.

5. Place the die on the end of the pipe so that the tapered portion of the die will begin the cut.

6. Lubricate the tap and workpiece with the proper lubricant.

7. Apply pressure on the die and turn the die stock slowly in a clockwise direction.

8. Once the die begins to cut threads, stop and apply lubricant.

9. Continue threading, without backing up, until all threads are cut.

10. Stop threading when one thread projects through the die.

11. Remove the die from the pipe by turning the die stock counter-clockwise.

12. Ream the end of the pipe to remove burrs.

13. Clean all equipment and return to the appropriate storage area.

14. Assign JS 9.5.

Job Sheet 9.1: Cutting Internal Threads With a Tap

Objective: At the completion of this job sheet, the student will be able to tap internal threads in a piece of metal.

Tools and Equipment Needed:

1. Drill press
2. Tap
3. Tap wrench
4. Try square
5. Safety glasses*

*CAUTION: Safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of metal
2. Threading lubricant

Procedure:

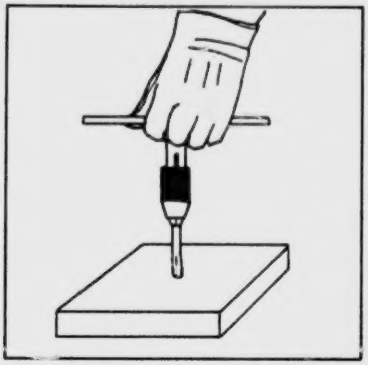


Figure 9.1

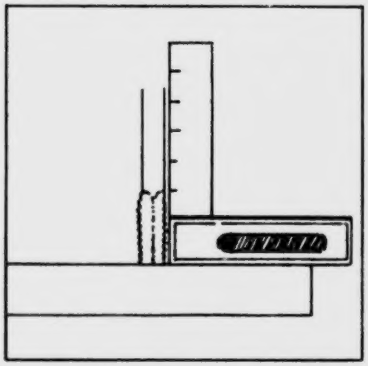


Figure 9.2

1. Using the drill press, drill the proper sized hole for tapping. Drill size = tap diameter - 1 + pitch.
2. Select the proper tap and insert the square end in the tap wrench.
3. Lubricate the tap and workpiece with the proper lubricant.
4. Hold the tap wrench with the hand directly over the tap. Place the tapered end of the tap in the drilled hole. See Figure 9.1.
5. Check to make certain that the tap is straight with the hole.
6. Apply downward pressure on the tap wrench while turning it in a clockwise direction for two turns.
7. Remove the tap wrench and use a try square or a combination square to make sure the tap is straight, as shown in Figure 9.2.
8. Place the tap wrench back on the tap.
9. Apply proper lubricant as necessary.
10. Place one hand on each end of the tap wrench, as shown in Figure 9.3.

11. Turn the tap clockwise one to two turns and then counter-clockwise for 1/2 turn.
12. Continue threading until the tap reaches the bottom of the blind hole or turns free after coming through the bottom of the hole drilled completely through the metal.
13. Remove lubricant and chips from the tap and tap wrench. Return them to the appropriate storage place.
14. Screw a correct sized bolt into the tapped hole to check for accuracy.
15. Turn in the metal to the instructor for grading.

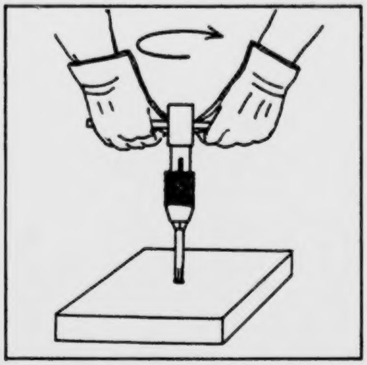


Figure 9.3

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Job Sheet 9.2: Cutting External Threads with a Die

Objective: At the completion of this job sheet, the student will be able to use a die to thread a rod.

Tools and Equipment Needed:

1. File
2. Die
3. Die stock
4. Vise
5. Safety glasses*

*CAUTION: Safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Threading lubricant
2. Piece of rod

Procedure:

1. Clamp the rod to be threaded in a vise.
2. Use a file to bevel the end of the rod, as shown in Figure 9.1.
3. Select a die the same size as the diameter of the rod and with the desired number of threads per inch.
4. Insert the die in the die stock.
5. Lubricate the tap and rod with the proper lubricant.
6. Place the die over the rod with the tapered side toward the rod.
7. Start the die by turning it in a clockwise direction while applying downward pressure. Make certain that the die starts squarely, as shown in Figure 9.2.
8. Once the die begins to feed itself, continue to apply the correct lubricant to the die and rod.

   NOTE: A split die or a two-piece split die can be adjusted to cut shallower or deeper. Check the thread depth with a new nut of the appropriate size. If the threads are too shallow, the nut will turn hard. If the threads are too deep, the nut will wobble. Adjust your die appropriately to achieve the desired thread depth.

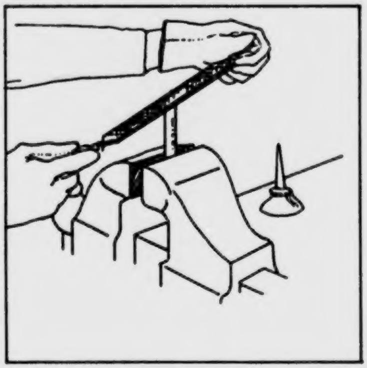

Figure 9.1

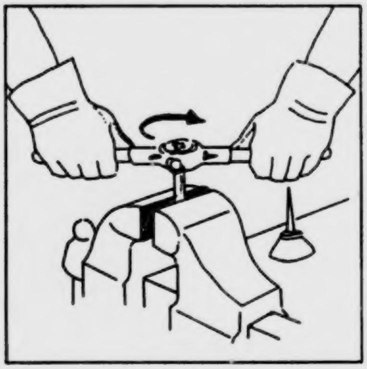

Figure 9.2

9. Continue threading the rod by turning the handle clockwise until the desired length of rod has been threaded.

10. Remove the die and die stock from the rod and remove lubricant and metal chips from them before returning them to the appropriate storage area.

11. Turn in the threaded rod to the instructor for grading.

Job Sheet 9.3: Using the Drill Press as a Precision Guide for Tapping

Objective: At the completion of this job sheet, the student will be able to tap threads in a piece of metal using the drill press as a precision guide.

Tools and Equipment Needed:

1. Drill Press
2. Chuck key
3. Lathe center
4. Tap
5. Tap wrench
6. Safety glasses*

*CAUTION: Safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Piece of metal
2. Threading lubricant

Procedure:

1. Select a piece of metal in which to drill and tap a hole.
2. Using the drill press, drill the correct size hole for the tap to be used.

CAUTION: After the hole is drilled, disconnect the drill press from the power source to avoid accidental starting while tapping. In the remaining portion of this exercise, the drill press is only used as a precision guide, not a power tool.

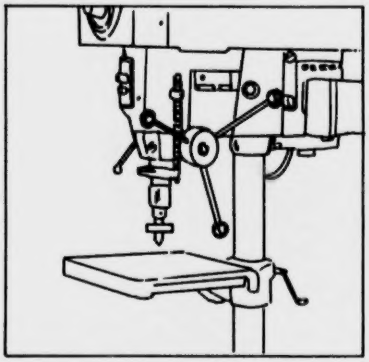

Figure 9.1

3. Remove the drill bit from the chuck of the drill press.
4. Insert and tighten a metal lathe center in the chuck of the drill press, as shown in Figure 9.1.
5. Place the tap wrench on the tap.
6. Align the tap with the hole in the metal.
7. Turn the pilot wheel of the drill press so that the lathe center is placed in the center hole in the shank end of the tap, as shown in Figure 9.2.
8. Lubricate the tap and workpiece with the proper lubricant.

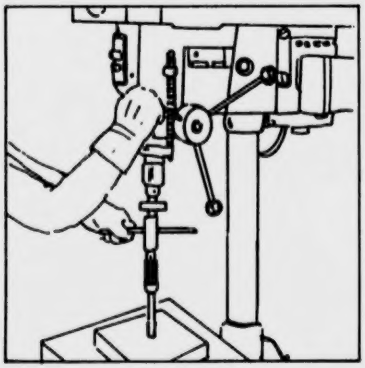

Figure 9.2

9. Turn the tap handle by hand while, at the same time, applying slight pressure with the pilot wheel of the drill press.

10. Continue until the threads are tapped to a sufficient depth.

11. Clean the tools and return them to the appropriate storage area.

12. Check the hole for accuracy.

13. Turn in the metal to the instructor for grading.

Job Sheet 9.4: Tapping a Hole With a Drill Press

Objective: At the completion of this job sheet, the student will be able to tap a hole using the tapping attachment on the drill press.

Tools and Equipment Needed:

1. Drill press
2. Drill bit
3. Chuck key
4. Tapping attachment
5. Tap
6. Clamp
7. Safety glasses*

*CAUTION: Safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Threading lubricant
2. Piece of metal

Procedure:

CAUTION: Never try to tap a hole without using the tapping attachment. The speed of the drill press will shatter the tap and possibly cause injury to the operator.

1. Select a piece of metal to work and clamp it to the table.
2. Using the drill press, drill the correct size hole for the tap to be used.
3. Connect the tapping attachment to the drill press according to manufacturer's directions.

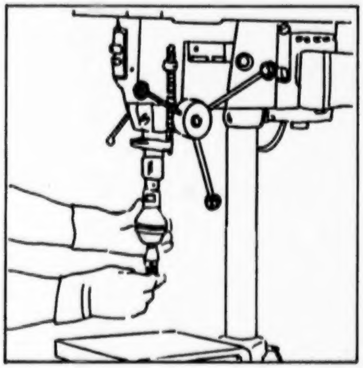

Figure 9.1

4. Insert the appropriate tap into the tapping attachment, as illustrated in Figure 9.1.
5. Align the metal on the table with the tap. Clamp it in place.
6. Preset the depth of the hole with the depth stop on the side of the drill press.
7. Lubricate the tap and workpiece with the proper lubricant.
8. Turn on the drill press and lower the tap into the hole using the pilot wheel of the drill press, as shown in Figure 9.2. Apply lubricant as needed.

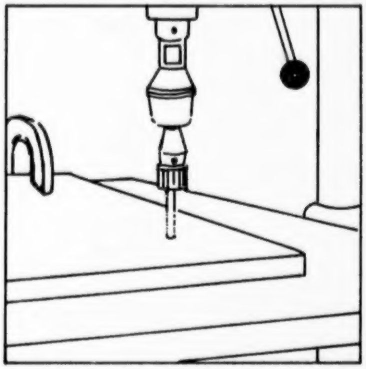

Figure 9.2

9. When the tap reaches the predetermined depth, the attachment will stop the tap from turning.
10. Raise the pilot wheel to back the tap out of the hole.
11. Clean the lubricant and metal chips from the metal and the drill press.
12. Check the hole for accuracy.
13. Turn in the metal to the instructor for grading.

Job Sheet 9.5: Cutting Pipe Threads

Objective: At the completion of this job sheet, the student will be able to cut threads on a pipe.

Tools and Equipment Needed:

1. Pipe vise
2. Pipe cutter
3. Pipe reamer
4. Die
5. Die stock
6. Safety glasses*

*CAUTION: Safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. Pipe
2. Threading lubricant

Procedure:

1. Secure the pipe in a pipe vise, as shown in Figure 9.1.
2. Cut the pipe to the required length using a pipe cutter, as shown in Figure 9.2.
3. Ream the inside of the pipe using a pipe reamer. Bevel the outside edge of the pipe, using the same technique as for beveling a rod.
4. Select the proper size of collet (guide) and die, and insert them in the die stock.
5. Place the die on the end of the pipe so that the tapered portion of the die will begin the cut.
6. Lubricate the tap and workpiece with the proper lubricant.
7. Apply pressure on the die and turn the die stock slowly in a clockwise direction, as shown in Figure 9.3.
8. Once the die begins to cut threads, stop and apply lubricant.
9. Continue threading, without backing up, until all threads are cut.
10. Stop threading when one thread projects through the die.

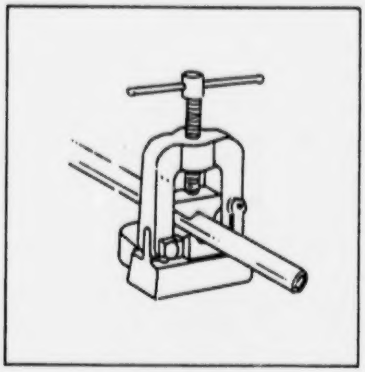
Figure 9.1

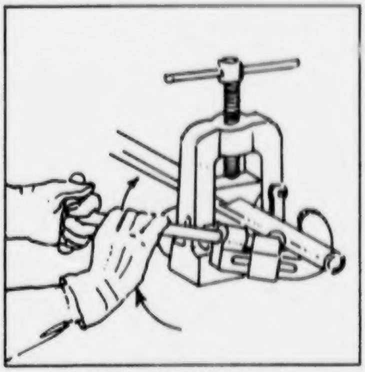
Figure 9.2

11. Remove the die from the pipe by turning the die stock counter-clockwise.

12. Ream the end of the pipe to remove cutting edges, as shown in Figure 9.4.

13. Clean all equipment and return to the appropriate storage area.

14. Turn in the metal to the instructor for grading.

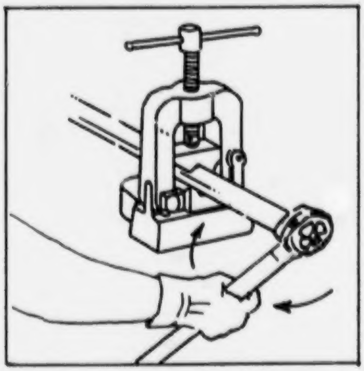

Figure 9.3

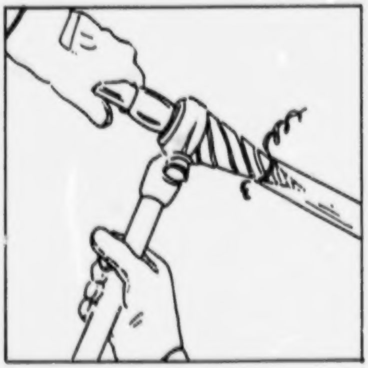

Figure 9.4

Lesson 10: Using Heat to Treat Metals

Objective: The student will be able to describe the methods of heat treatment and their effects on metal.

Study Questions

1. **What is crystallization?**
2. **What heat treatment methods are used to control crystallization?**
3. **Why are metals annealed?**
4. **Why are metals normalized?**
5. **Why is hardening used for metals?**
6. **Why are metals tempered?**
7. **What effect does welding have on crystallization?**
8. **What is wrinkle bending?**

References

1. Handout
    - a) HO 10.1: Treating Metals with Heat
2. Demonstration Sheet
    - a) DS 10.1: Making a Cold Chisel
3. Job Sheet
    - a) JS 10.1: Making a Cold Chisel

Lesson 10: Heat Treating Metals

TEACHING PROCEDURES

A. Review

Review the previous lesson on hand and machine threading.

B. Motivation

Place a small amount of sugar in a container that is suitable for heating. Using the torch or a furnace, heat the sugar until it melts. A teaspoon and a disposable lighter may be used if a torch or a furnace is not available. Remove the heat from the sugar and cool it quickly. Point out the small crystals that will form when the sugar begins to cool. Reheat the sugar and let it cool at room temperature. Point out the larger crystals that are formed from the slow cooling.

C. Assignment

D. Supervised study

E. Discussion

1. Refer back to the motivation and ask students to define crystallization.

   What is crystallization?

   Crystallization is the formation of crystals when a metal moves from a liquid state to a solid state.
   a) When metal is cooled slowly, a large grain structure will result.
   b) When metal is cooled quickly, a finer grain structure will result.
   c) The type of grain structure desired will depend on the use of the metal.

2. Discuss the heat treatments that are available for improving the physical properties of metal. Ask the students to define each.

   What heat treatment methods are used to control crystallization?

   a) Annealing
   b) Normalizing
   c) Hardening
   d) Tempering

3. Ask students to describe why the procedure for annealing is important for metals that are to be machined.

   Why are metals annealed?

   a) The metal is heated above the critical temperature and then cooled slowly in an insulating material such as sand, lime, or ashes.

b) Internal stress of the metal is reduced which will allow the metal to be machined with less chance of cracking.

4. Ask students to explain the normalizing process and how it differs from annealing.

Why are metals normalized?

a) The metal does not become as soft during the normalizing process as it does in the annealing process, but it is still workable.
b) Normalizing is generally used on low-carbon steels because annealing may cause them to become too soft.

5. Ask the class to explain why hardening would be necessary for metals.

Why is hardening used for metals?

a) If the metal is not hardened after annealing, the strength of the metal is greatly reduced.
b) Hardening causes the carbon in the metal to be brought to the surface of the metal to increase the metal's strength.
c) The lower the carbon content of the steel, the less effect hardening will have on the hardness.
d) When heating the metal for hardening, you should avoid overheating, since too much heat will change the entire structure of the metal, rather than the surface structure only.
e) Once the surface metal has been heated to slightly above the critical temperature, the metal is dipped in water, oil, or brine to cool it quickly.
    1) Carbon steels are usually cooled in water or brine.
    2) Alloy steels are cooled in oil.

6. Ask the class to explain why metals are tempered after other heat treatments have been used.

Why are metals tempered?

a) Tempering is used to reduce internal stresses in the metal and to reduce the brittleness.
b) Some hardness and strength is lost during tempering, but the metal will become more impact resistant.
c) In tempering, the metal is heated to below the critical temperature, so less physical changes are occurring than in annealing or normalizing.
d) The metal is cooled by dipping it in water or oil.

7. Ask the class to describe the effect that welding would have on the grain structure of a metal.

What effect does welding have on crystallization?

a) Welding involves high temperatures when the metal is heated to a molten (liquid) state.
b) A variety of grain structures is present in the heat-affected zone of the metal being welded.

c) Heat treatment may be needed in metals with higher carbon levels to improve the strength of the metal.
d) Low-carbon steels may not need heat treatment since the heating of the metal will not have as severe of an effect as it will in high-carbon metals.

8. Elbows are usually used when changing the direction in which a pipe runs. Discuss the use of wrinkle bending with the class as an alternative to using an elbow.

What is wrinkle bending?

a) Wrinkle bending uses a series of small bends to get the desired angle of bend, while keeping the inside diameter of the pipe approximately the same.
b) A maximum of a twelve degree bend can be done at one time.
c) Only one-half of the circumference of the pipe is heated when wrinkle bending.

F. Other activities

1. Prepare a display of various metals that have been bent to illustrate the effect of the bend on the properties of the metal.

2. Students should use heat to bend different types of metal to observe the temperature required for a good bend.

G. Conclusion

Several methods are used to treat metal to improve its characteristics for both machining and use. These heat treatments are used in combination with each other to provide a high quality project that is functional.

H. Competency

List steps used in tempering, annealing, hardening, wrinkle bending, normalizing, and welding to control crystallization.

I. Answers to Evaluation

1. b
2. b
3. d
4. e
5. d
6. To improve the physical characteristics so that the metal will be more workable and durable

UNIT IV - METALS

Name ________________

Lesson 10: Using Heat to Treat Metals

Date ________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. The formation of crystals when a metal moves from a liquid state to a solid state is called ______________.

   a. Transformation
   b. Crystallization
   c. Annealing
   d. Normalization
   e. Tempering

2. The procedure in which metal is heated above the critical temperature, then cooled slowly in sand, lime, or ashes is called ______________.

   a. Normalizing
   b. Annealing
   c. Hardening
   d. Tempering
   e. Crystallization

3. A process used to restore hardness to the surface of the metal after it has been annealed is called ______________.

   a. Normalizing
   b. Crystallization
   c. Tempering
   d. Hardening
   e. Annealing

4. A procedure where metal is heated to the critical temperature and cooled at room temperature is called ______________.

   a. Tempering
   b. Crystallization
   c. Hardening
   d. Annealing
   e. Normalizing

5. A process done shortly after hardening to soften the metal is called ______________.

   a. Normalizing
   b. Annealing
   c. Crystallization
   d. Tempering
   e. Hardening

6. Why is heat treatment used on metals?

Metal undergoes many changes when heat is applied, as well as when it begins to cool. It is important to understand the types of changes that occur and their effect on the durability and strength of the metal.

Crystallization

Crystallization is the formation of crystals when metals move from a liquid state to a solid state. The presence of high amount of heat will cause the grain structure of a metal to change during the cooling process. If the metal is heated to a high temperature and then cooled slowly, a large grain structure in the metal will result. On the other hand, if the metal is cooled quickly, a finer grain structure will occur. The type of grain structure to create in the metal will depend on the use of the metal. Several forms of heat treatment are used in order to alter the original grain structure of the metal to provide the needed physical and mechanical properties.

Heat Treatment

Heat treatment of metals includes the procedures of heating as well as cooling of the metal. There are many different types of heat treatments for metals you can choose, depending on the type of results you wish to achieve. Among the processes used in agricultural construction are: annealing, normalizing, hardening, and tempering.

Annealing

Annealing reduces the hardness of a metal so that it may be machined more easily. As a result of the annealing process, the internal stress of the metal is reduced which will allow the metal to be machined with less chance of cracking. The metal is heated above the critical temperature and then cooled slowly in an insulating material such as sand, lime, or ashes.

Normalizing

Normalizing is a process similar to annealing where the metal is heated to the critical temperature, except that it is cooled at room temperature. The metal does not become as soft during the normalizing process as it does in the annealing process, but it is still workable. Normalizing is generally used on low-carbon steels because annealing may cause them to become too soft.

Hardening

The hardening process restores the hardness to the surface of the metal after it has been annealed or normalized, while allowing the inside of the metal to remain soft and ductile. If the metal is not hardened after annealing, the strength of the metal is greatly reduced. Hardening causes the carbon in the metal to be brought to the surface of the metal to increase the metal's strength. The lower the carbon content of the steel, the less effect hardening will have on the hardness. When heating the metal for hardening, you should avoid overheating, since too much heat will change the entire structure of the metal, rather than the surface structure only. Once the surface metal has been heated to slightly above the critical temperature (dull red color), the metal is dipped in water, oil, or brine to cool it quickly. Carbon steels are usually cooled in water or brine, while alloy steels are cooled in oil.

Tempering

Tempering is a process that is done shortly after hardening to increase toughness and ductility by softening the metal. Tempering is used to reduce internal stresses in the metal and to reduce the brittleness. Some hardness and strength is lost during tempering, but the metal will become more impact resistant. In tempering, the metal is heated to below the critical temperature, so less physical changes are occurring than in annealing or normalizing. The metal is cooled by dipping it in water or oil.

Effect of Welding on Crystallization

The process of welding can have a measurable affect on the process of crystallization in metal. Welding involves high temperatures when the metal is heated to a molten (liquid) state. As discussed earlier, the grain particles in metal change structure as the temperature of the metal increases. A variety of grain structures is present in the heat affected zone of the metal being welded. Because of the effects of heat while welding, heat treatments may be needed in metals with higher carbon levels to improve the strength of the metal. Low-carbon steels may not need heat treatment since the heating of the metal will not have as severe of an effect as is will in high-carbon metals.

Wrinkle Bending

Wrinkle bending is used when you do not want to decrease the diameter of the pipe at the bend. Elbows have nearly replaced the need for wrinkle bending, so it is usually only used when an elbow of the correct angle and size is not available. To perform a wrinkle bend, the metal is heated on one side where the bend is to occur. The pipe is then bent to a maximum of twelve degrees. The metal is heated slightly past the first bend and bent to another twelve degrees. This process is continued until the proper angle is achieved. The slight bends allow for the bend to occur without reducing the inside diameter of the pipe.

Summary

Several types of processes are used to heat treat metal. When metal is exposed to high levels of heat, the grain structure is altered. The correct process should be chosen, based on the desired strength and use of the metal being treated. Proper heating and cooling procedures must be followed for the desired results to occur.

Credits

Introductory Welding Metallurgy. Miami, FL: American Welding Society, 1968.

Morford, V. J.; Thomas A. Hoerner; Willard R. Anderson. Metals and Welding. St. Paul, MN: Hobar Publications, 1970.

Walker, John R. Modern Metalworking. South Holland, IL: The Goodheart-Willcox Company, Inc., 1985.

Demonstration Sheet 10.1: Making a Cold Chisel

Objective: At the completion of this demonstration, the student will be ready to make a cold chisel, using the proper heat treatment methods.

Equipment Needed:

1. Oxy-acetylene torch
2. Anvil
3. Blacksmith's hammer
4. Tape measure
5. Metal file
6. Wire brush
7. Bench grinder
8. Pliers
9. Gloves
10. Safety goggles*
11. Welding goggles*

*CAUTION: Welding goggles and safety glasses must be worn by all students observing the demonstration. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. 1 1/2" x 5" hexagon high carbon rod
2. Insulating material - sand, lime, or ashes
3. Bucket of water

Procedure:

1. Heat the lower 2" of the rod until it reaches a cherry red color.

   CAUTION: Hot metal should be handled with pliers. Gloves will not give adequate protection to pick up hot metal.

2. Taper the heated end with an anvil and a hammer. The taper should begin on the cutting end and end about 2" up the rod. The end of the tip should be 3/16" thick and 5/8" wide.

3. Anneal the cold chisel by heating the entire chisel to a cherry red color and allowing it to cool slowly in an insulated material, such as sand, lime, or ashes. This will take about 24 hours to properly cool.

4. Using a metal file, remove the oxides from the cutting tip of the chisel.

5. Temper the cold chisel by heating 3" on the cutting end of the chisel to a cherry red color.

6. Cool the chisel in water until the steam stops. Do not completely cool the cold chisel since it has not been tempered yet. Move the chisel up and down slightly in the water to avoid causing cracks at the water line as a result of uneven cooling.

7. Remove the chisel from the water. Remove the oxides that have formed on the cutting end by using a wire brush or file.

8. Once the oxides have been removed, you can observe the temper color of the metal. Since the metal was not completely cooled, some of the heat will still be in the unworked shank of the chisel. This heat will eventually work its way down to the cutting tip. When the cutting tip becomes purple, completely cool the chisel in cold water.

9. Grind a 60-degree angle on the cutting end of the chisel.

10. The opposite end of the chisel should be tapered slightly with the bench grinder to prevent mushrooming when the hammer strikes the chisel.

11. Clean the chisel and examine it for accuracy.

Job Sheet 10.1: Making a Cold Chisel

Objective: At the completion of this job sheet, the student will be able to make a cold chisel, using the proper heat treatment methods.

Equipment Needed:

1. Oxy-acetylene heating tip
2. Anvil
3. Ball peen hammer
4. Tape measure
5. Metal file
6. Wire brush
7. Bench grinder
8. Pliers
9. Gloves
10. Safety goggles*
11. Welding goggles*

*CAUTION: Welding goggles and safety glasses must be worn by all students performing the job sheet. Safety practices should be followed at all times while in the shop area.

Materials Needed:

1. 1 1/2" x 5" hexagon high carbon rod
2. Insulating material - sand, lime, or ashes
3. Bucket of water

Procedure:

1. Heat the lower 2" of the rod until it reaches a cherry red color, as shown in Figure 10.1.

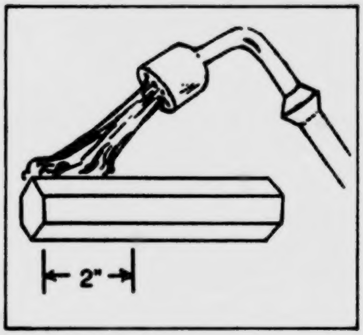

Figure 10.1

2. Use an anvil and a hammer to taper the heated end of the rod. The taper should begin on the cutting tip and end about 2" up the rod, as illustrated in Figure 10.2. The end of the tip should be 3/16" thick and 5/8" wide.
3. Anneal the cold chisel by heating the entire chisel to a cherry red color and allowing it to cool slowly in an insulated material, such as sand, lime, or ashes. This will take about 24 hours to properly cool.
4. Using a metal file, remove the oxides from the cutting tip of the chisel.

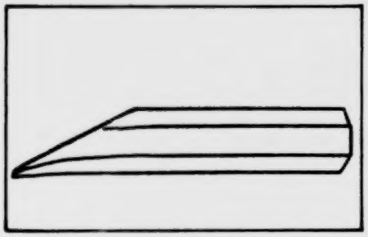

Figure 10.2

5. Temper the cold chisel by heating 3" on the cutting end of the chisel to a cherry red color.
6. Cool the chisel in water until the steam stops. Do not completely cool the cold chisel since it has not been

tempered yet. As you are cooling the chisel, move it slightly up and down in the water to avoid causing cracks at the water line as a result of uneven cooling, as pictured in Figure 10.3.

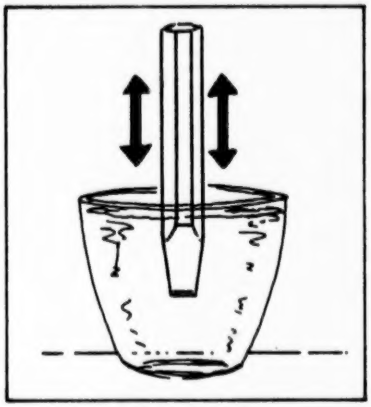

Figure 10.3

7. Remove the chisel from the water. Remove the oxides that have formed on the cutting end by using a wire brush or file.

8. Once the oxides have been removed, you can observe the temper color of the metal. Since the metal was not completely cooled, some of the heat will still be in the unworked shank of the chisel. This heat will eventually work its way down to the cutting tip. When the cutting tip becomes purple, completely cool the chisel in cold water.

9. Grind a 60-degree angle on the cutting end of the chisel, as shown in Figure 10.4.

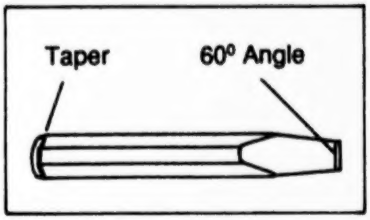

Figure 10.4

10. The opposite end of the chisel should be tapered slightly with the bench grinder to prevent mushrooming when the hammer strikes the chisel. (See Figure 10.4.)

11. Clean the chisel and examine it for accuracy.

12. Turn the chisel in to the instructor for grading.

UNIT V - FINISHING

GETTING READY FOR THIS UNIT

The information presented in this unit is a continuation of the information included in the Agricultural Science I and II core curriculums. Information from the core curriculum should be reviewed before presenting the information in this unit.

CONTENTS

Lesson 1–Preparing Surfaces for Finishing V-1
    HO 1.1: Surface Preparation
Lesson 2–Selecting Primer V-11
    HO 2.1: Properties of Common Paint Systems
    HO 2.2: Types of Exterior Primers
Lesson 3–Selecting Paint V-23
    HO 3.1: Selecting Paint
Lesson 4–Painting and Cleanup V-33
    HO 4.1: Painting and Cleanup

OBJECTIVES

1. The student will be able to properly prepare metal and wood for finishing.
2. The student will be able to select the proper primer for the surface to be painted.
3. The student will be able to select paint.
4. The student will be able to paint a surface using the proper method and clean up after the operation is complete.

COMPETENCIES

1. Prepare surfaces for finishing.
2. Select the primer to use before painting the surface.
3. Select the paint to use in the finish operation.
4. List the steps for cleanup after finishing operation is complete.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Bring lumber samples of several different surfaces (e.g., rough-sawed, sanded) into the classroom. Also bring several kinds of paint. Have students match the surface to the paint. Ask what criteria they used for matching the paint to the surface. Lead the discussion to emphasize that not all paints are appropriate for all surfaces.

2. Bring two pieces of metal into the classroom. One should be rusty and oily, while the other is sanded and clean. Ask students which piece of metal will hold paint better. Discuss methods of preparing the metal for finishing. Provide some pieces of metal in which the paint is peeling or cracking. Have students explain why this is occurring.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

    a) Agricultural Construction, Volume II (Student Handouts). University of Missouri-Columbia: Instructional Materials Laboratory, 1989.

2. Teacher References

    a) "Agricultural Mechanics Unit", Agricultural Science I and II Core Curriculums, University of Missouri-Columbia: Instructional Materials Laboratory.

    b) Cooper, Elmer L. Agricultural Mechanics: Fundamentals and Applications. 1st ed. Albany, NY: Delmar Publishing, 1987.

    c) Giachino, Joseph W. and William Weeks. Welding Skills. 1st ed. Alsip NY: American Technical Publishers, 1986.

    d) "Paints and Painting", VAS 3053. Urbana, IL: Vocational Agriculture Service.

    e) Paint and Wallpaper. New York: Time-Life Books, 1977.

Agricultural Construction
Unit V - Finishing
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale: 3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N	**Finishing**
				1. Prepare surfaces for finishing
				2. Select the primer to use before painting the surface
				3. Select the paint to use in the finish operation
				4. List the steps for cleanup after finishing operation is complete
				Other (specify)
				______________________________
				______________________________

Agricultural Construction
Unit V - Finishing

Class/Section: ____________________

Students:	Prepare surfaces for finishing	Select the primer to use before painting the surface	Select the paint to use in the finish operation	List the steps for cleanup after finishing operation is complete							

UNIT V - FINISHING

Lesson 1: Preparing Surfaces for Finishing

Objective: The student will be able to properly prepare metal and wood for finishing.

Study Questions

1. **What safety precautions should be taken when preparing metal or wood surfaces for finishing?**
2. **How are metal surfaces prepared for finishing?**
3. **What are MIG whiskers and how are they removed?**
4. **What methods should be used to prepare wood surfaces for finishing?**

Reference

1. Handout
    a) HO 1.1: Surface Preparation

UNIT V - FINISHING

Lesson 1: Preparing Surfaces for Finishing

TEACHING PROCEDURES

A. Introduction

Introduce the unit.

B. Motivation

Show students two painted metal pieces, one that has a good paint coat, the other with paint peeling. Ask students to determine what could have caused the difference in the paint adherence to the surfaces.

C. Assignment

D. Supervised study

E. Discussion

1. The use of equipment and chemicals can make surface preparation of metal and wood hazardous if safety precautions are not observed. Ask the students to list the safety precautions that should be taken when preparing metal or wood surfaces.

   What safety precautions should be taken when preparing metal or wood surfaces for finishing?

   a) Safety glasses should be worn at all times.
   b) Follow safety precautions for equipment used.
   c) Protective clothing should be worn to protect the body.
   d) Follow precautions listed on the label for any chemicals used.
   e) Read the directions on chemical labels for mixing and using the chemical.
   f) Proper ventilation and use of a respirator is required.
   g) Remove flammable materials from the finishing area.
   h) If chemicals get in your eyes, rinse them immediately and seek medical attention.
   i) Always wash hands after using chemicals.
   j) Clean up any spills as they occur.
   k) Properly dispose of used rags and other items contaminated with chemicals that are not to be cleaned and used again.

2. The type of preparation needed for metal will depend on whether or not the surface of the metal has been painted previously. Ask students to list the proper methods used to prepare new and previously painted surfaces for finishing.

   How are metal surfaces prepared for finishing?

   a) Unpainted metal
      1) Remove slag from welds.
      2) Remove dirt and rust with a wire brush, emery cloth, sandpaper, or a wire wheel on a portable grinder. (If using a wire wheel, a face shield should be worn.)

        3) Remove oil and grease with a detergent, chemicals, steam cleaner, or high-pressure washer.

        CAUTION: Safety is important when using a steam cleaner. The heat from the steam can cause burns. The use of chemicals makes it necessary to observe extreme care when using the equipment. Refer to the manufacturer's handbook and the chemical label for safe use. Since the steam cleaner uses water, electrical safety must be observed.

        4) Remove all residues from the detergent or chemical with a clean cloth.
        5) Let the metal surface dry completely and apply a coat of primer before the surface becomes contaminated. New galvanized metal should be coated with primer specifically designed for galvanized metal to avoid a harmful chemical reaction which will cause the primer to lose its adhesive ability.
    b) Painted metal
        1) Remove old paint, dirt, and rust with a scraper, wire brush, or chemical stripper.
        2) Oil and grease are removed with a steam cleaner or chemical stripper.
        3) Any old paint that cannot be removed should be sanded so that the edges blend into the surface of the metal to prevent peeling.
        4) Wash the surface of the metal with a clean cloth to remove chemical residue. (Certain applications may require chemical treatment.)
        5) Let the surface of the metal dry completely and apply a coat of primer before the surface becomes contaminated.

3. If problems are encountered when starting the arc, the MIG welder has a tendency to leave "whiskers" in the weld. Before the project is painted, it is necessary to remove these whiskers. Ask students to describe a MIG whisker and list possible ways to remove these whiskers.

What are MIG whiskers and how are they removed?

    a) Whiskers are short lengths of electrode wire sticking through the weld joint that have been left from the MIG welder.
    b) Remove by filing or grinding so that the welded area is smooth.

4. Though the method of preparing wood for finishing is similar to metal, some different steps are needed to provide a quality finish. Ask students to describe the methods necessary to properly prepare wood for finishing.

What methods should be used to prepare wood surfaces for finishing?

    a) Unfinished wood
        1) Holes should be repaired by putty, wax, plugs, fillers, or plastic wood.
        2) Sealer should be used on the wood to reduce the shrinking of the putty or filler.
        3) Dents can be fixed by adding hot water to the surface causing the wood to swell and fill the dent.
        4) The wood may be bleached to lighten the color if necessary.
        5) Sand the surface of the wood if a smooth finish is desired.
    b) Painted wood
        1) Remove old paint with a wire brush, scraper, sandpaper, or stripper.
        2) Wash the wood with detergent, ammonia, or trisodium phosphate to remove residues and dust.

    3) Seal the wood to extend the life of the paint job.
    4) Caulk cracks, repair dents, and fill holes.
    5) Sand the surface of the wood if a smooth finish is desired.

F. Other activities

1. Show students previously painted projects in which preparation was done properly and in which preparation was done improperly.

2. Take students to a local machinery dealer, and inspect new machinery for proper preparation of surfaces before the painting was done.

3. Have a local body shop worker speak to the class concerning preparation methods of metal.

4. Give each student a piece of scrap lumber and metal to prepare for finishing. Award the student who performs the best preparation.

G. Conclusion

Because the quality of the paint job on any surface depends so much on the preparation of the surface, care must be taken to prepare the surface properly. Proper equipment and methods must be used. Care should be taken when using solvents, as combustible or flammable materials are dangerous in any laboratory. Safety should always be a primary concern.

H. Competency

Prepare surfaces for finishing.

I. Answers to Evaluation

1. Five safety precautions that were discussed in class should be listed.
2. Two of the following: wire brush, emery cloth, sandpaper, or wire wheel
3. Two of the following: detergent, chemicals, steam cleaner, or high-pressure washer
4. Short lengths of electrode wire sticking out of the weld
5. Two of the following: putty, wax, plugs, fillers, or plastic wood
6. Add hot water to be absorbed by the wood.

UNIT V - FINISHING

Name ____________________

Lesson 1: Preparing Surfaces for Finishing

Date ____________________

EVALUATION

Complete the following short answer questions.

1. What are five safety precautions that should be followed when preparing surfaces for finishing?

   a.

   b.

   c.

   d.

   e.

2. What are two methods of removing dirt and rust from a metal surface?

   a.

   b.

3. What are two methods of removing oil and grease from a metal surface?

   a.

   b.

4. What are MIG whiskers?

5. What are two methods of repairing holes in wood?

   a.

   b.

6. How can a dent in wood be smoothed out?

The life of a project can be extended several years if it is given a good paint job when construction is complete. The quality of the paint job depends on the quality of the surface preparation before painting. Most defects are still noticeable, maybe more noticeable, if they are not repaired before painting is done. The time invested in preparing the surface will be worth it in the long run since the life of the paint job will increase the life of the project.

Safety Precautions

As with any type of work in the agricultural shop, the safety of yourself and those around you should be your first consideration. The use of equipment and chemicals to prepare the surface of wood and metal for painting creates hazards that should be considered when working in the shop. Safety precautions that should be followed are listed below.

1) Safety glasses should be worn at all times.
2) Follow safety precautions for equipment used.
3) Protective clothing should be worn to protect the body.
4) Follow precautions listed on the label for any chemicals used.
5) Read the directions on chemical labels for mixing and using the chemical.
6) Proper ventilation and use of a respirator is required.
7) Remove flammable materials from the finishing area.
8) If chemicals get in your eyes, rinse them immediately and seek medical attention.
9) Always wash hands after using chemicals.
10) Clean up any spills as they occur.
12) Properly dispose of used rags and other items contaminated with chemicals that are not to be cleaned and used again.

Metal Surfaces

The type of preparation needed for metal will depend on whether or not the surface of the metal has been previously painted. When preparing metal that has not been painted, you should remove the slag from all welds with a chipping hammer and a wire brush. All dirt and rust should be removed from the metal with a wire brush, emery cloth, sandpaper, or a wire wheel on a portable grinder. If using a wire wheel, a face shield should be worn. Oil and grease can be removed by using detergent, chemicals, steam cleaner, or high-pressure washer. Safety is important when using a steam cleaner. The heat from the steam can cause burns and the use of chemicals make it necessary to observe extreme care when using the equipment. Refer to the manufacturer's manual and the chemical label for directions for safe use. Since the steam cleaner uses water and electricity, electrical safety is a serious consideration. After you have cleaned the metal, all residue should be removed from the surface with a clean cloth. Let the metal surface dry completely and apply a coat of primer before the surface becomes contaminated. A specially designed galvanized metal primer should be used to avoid a harmful chemical reaction between the zinc in the metal and the primer, which will result in a loss of adhesive power.

If the metal has been previously painted, extra work may be required to get the metal surface into condition to accept a new coat of paint. Remove all old paint, dirt, and rust with a scraper, wire brush, or chemical stripper. Any old paint that cannot be removed should be sanded so that the edges blend into the surface of the metal to prevent peeling after new paint is applied. Wash the surface of the metal with a clean cloth to remove chemical residue. Certain applications may require chemical treatment. After the surface of the metal dries completely, apply a coat of primer before the surface becomes dirty again or begins to rust.

Removing Whiskers

If a gas metal arc welding machine (MIG) is used to construct the project, there is a possibility that whiskers have been left in or around the weld. Whiskers are short lengths of electrode wire sticking through the weld joint that have been left from the welding process. Before the project is painted, it is necessary to remove these whiskers. They are easily removed by filing or grinding.

Wood Surfaces

Though the method of preparing wood for finishing is similar to metal, some different steps are needed to provide a quality finish. For unpainted wood, any holes in the surface should be repaired before painting. Putty, wax, plugs, fillers, or plastic wood can be used to fill in holes. If putty is used, the wood should be sealed prior to applying the putty, in order to prevent shrinking of the putty or filler. Dents in the surface of wood can be repaired by adding hot water to the surface of the wood where the dent occurs. The absorption of the water into the wood will level the dent out. If a smooth surface is desired, sandpaper should be used after the wood dries. When sanding, follow the grain of the wood to get the best results. If a light or clear finish is to be used, the wood may be bleached to lighten its color or to remove stains from the surface.

If the wood has been painted before, the old paint should be removed with a wire brush, scraper, sandpaper, or stripper. A propane torch used in combination with a scraper is effective in removing old paint that cannot be scraped off. Safety should be observed when using the propane torch. After the old paint has been removed, wash the wood with detergent, ammonia, or trisodium phosphate to remove residues and dust. Allow the wood to dry before sanding or painting. Seal the wood to extend the life of the paint job and the wood. Dents and holes should be repaired before the paint is applied. Cracks can be filled with caulk and sanded level to provide a uniform surface. Sand the wood if a smooth surface is desired.

Summary

Good surface preparation is the key to a good paint job. Paint will not always cover up defects in the project, it sometimes makes them more noticeable. After spending time to construct a project, the additional time spent on surface preparation and finishing will be worth the effort.

Credits

Agricultural Science I Core Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

Cooper, Elmer L. Agricultural Mechanics: Fundamentals and Applications. 1st ed. Albany, NY: Delmar Publishing, 1987.

"Paints and Painting." VAS 3053, Urbana, IL: Vocational Agriculture Service.

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UNIT V - FINISHING

Lesson 2: Selecting Primer

Objective: The student will be able to select the proper primer for the surface to be painted.

Study Questions

1. **Why is primer used?**
2. **How is a primer selected?**
3. **What types of primer are available?**
4. **How is primer mixed and thinned?**
5. **What considerations should be made when applying primer?**

References

1. Handouts
   - a) HO 2.1: Properties of Common Paint Systems
   - b) HO 2.2: Types of Exterior Primers

Lesson 2: Selecting Primer

TEACHING PROCEDURES

A. Review

Review the previous lesson on preparing surfaces for finishing.

B. Motivation

Improper selection of a primer can inhibit the success of a painting process. The correct primer must be selected and handled properly in order to achieve maximum success and beauty of the finished product. Have students look at past paint jobs, and discuss the characteristics that make them acceptable or not.

C. Assignment

D. Supervised study

E. Discussion

1. To prime means to add an undercoating that prepares a surface for painting. Ask students why primer is needed on projects made in the agricultural education shop.

   Why is primer used?

   a) Prevent excess absorption of the paint
   b) Make the surface to be painted compatible with the paint to be used
   c) Provides a "tooth" for the paint to adhere to
   d) Closes up porous surfaces
   e) Inhibits rust on metal surfaces

2. Several factors should be considered when selecting the right primer to be used on a project. Discuss these factors with the class.

   How is a primer selected?

   a) Compatible with surface and paint to be used (Read the label.)
   b) Type of surface
   c) Vehicle type
   d) Drying time
   e) Special characteristics of the primer

3. Primers differ in their characteristics and compatibility with other materials. Use HO 2.2 to discuss the types of exterior primers. Ask the students to select from a group of different primers the proper one to use for a given base.

   What types of primer are available?

   a) Ferrous metals and aluminum

        1) Alkyd-based, rust inhibitive - dry time: touch - 2 to 4 hrs., recoat-overnight; new or painted surfaces; withstands climate extremes; thinning not required; clean with mineral spirits
        2) Epoxy-based, rust inhibitive - dry time: touch - 1 hr., recoat - overnight; used under epoxy enamel paint; must be mixed with hardener; resistant to most solvents and cleaners; thinning not required; clean with epoxy thinner
        3) Phenolic-based alkyd, rust inhibitive - dry time: touch - 1 hr., recoat - 3-4 hrs.; new or painted surfaces; can complete finish job in one day due to quick drying; no thinning required; clean with mineral spirits
    b) Galvanized metal
        1) Vinyl-acrylic latex - dry time: touch - 1 hr., recoat - 4 hrs.; painted or unpainted rust-free surfaces; high humidity will increase drying time; can be used as a finishing paint; no thinning required; clean with water
    c) Masonry (concrete)
        1) Phenolic-alkyd - dry time: touch - 2 hrs., recoat - 24 hrs.; new or painted surfaces; resistant to soap and detergent; washable; one coat sufficient; add clean sand to surfaces that are to be non-skid; thin and clean with mineral spirits
        2) Epoxy-modified acrylic latex - touch: 1 hr., recoat - overnight; new or painted surfaces; first coat on new concrete should be thinned with water; no thinning is required for painted surfaces; resistant to oil, detergent, and grease; add clean sand for non-skid surfaces
        3) Epoxy-ester enamel - dry time: touch 3-6 hrs., recoat - 24 hrs.; new or painted surfaces; resistant to chemicals, acids, and grease; resists hard wear; add clean sand for non-skid surfaces; thin and clean with epoxy thinner
    d) Wood
        1) Alkyd-based - dry time: 6 hrs., recoat - overnight; best for new surfaces, easy to apply with a brush, roller, or sprayer; good for chalky surfaces; thinning not required; clean with mineral spirits
        2) Alkyd-oil based - dry time: touch - 6 hrs., recoat - 24 hrs.; painted or unpainted surfaces; uniform seal on porous surfaces; good on chalky surfaces; thinning not required; clean with mineral spirits
        3) Latex-based - dry time: touch - 1 hr., recoat 2-4 hrs.; painted or unpainted surfaces; many do not require thinning; clean with water

4. Not all primers must be mixed or thinned before they are applied. Discuss the types of primers that require mixing or thinning to receive the best results. Refer to HO 2.2.

How is primer mixed and thinned?

a) Many primers are ready to apply without mixing or thinning.
b) Read and follow label instructions for mixing and thinning the primer.
    1) Latex primers should be thinned with water.
    2) Oil and alkyd-based primers are thinned with mineral spirits.
    3) Epoxy-based primers are thinned with epoxy thinner.
    4) Most epoxy primers are mixed with a hardener.

5. Primer should be applied under the proper conditions in order to achieve the best adhesion for the topcoat to be applied. Discuss the considerations to be made when applying primer.

What considerations should be made when applying primer?

a) Read the label for special instructions.
b) The surface to be primed should be clean and properly prepared.
c) Air temperature and surface temperature should be at least 50 degrees.
d) Stir well before using.
e) Most primers can be brushed, rolled, or sprayed.
f) Spraying may require thinning. Avoid over-thinning or the quality of the primer will be reduced.
g) Observe safety precautions when using primer.

F. Other activities

1. Have students select primer for their project.

2. Get a paint supply catalog from a local paint supplier to illustrate the types and prices of primers.

3. Compare and contrast two separate items, one which has been primed, the other which has not been primed.

G. Conclusion

Selection of the proper primer is very important to enhance the looks and prolong the wear and life of the painted material. An improper primer could cause blistering, cracking, peeling and flaking, and non-adherence of final paint coats.

H. Competency

Select the primer to use before painting the surface.

I. Answers to Evaluation

1. c
2. b
3. b
4. e
5. a
6. c
7. d
8. b
9. a
10. c

UNIT V - FINISHING Name ____________________

Lesson 2: Selecting Primer Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a use of primers?

   a. Rust inhibitor
   b. Close porous surfaces
   c. Avoid painting
   d. Provide a "tooth" for holding paint
   e. Make the surface compatible with the paint

2. Which of the following is a factor to consider when selecting a primer?

   a. Time of day the primer is bought
   b. Type of surface to be primed
   c. The alcohol content of the primer
   d. The number of coats of paint required
   e. Weight of the primer

Match the following surface with the correct vehicle type.

3.	______	Galvanized metal	a.	Phenolic-based/alkyd, rust inhibitive
4.	______	Ferrous metal	b.	Vinyl-acrylic latex
5.	______	Aluminum	c.	Alkyd/oil-based
6.	______	Wood	d.	Epoxy-modified acrylic latex
7.	______	Masonry	e.	Epoxy-based rust inhibitive

Match the following primers with the correct thinner.

8.	______	Latex	a.	Epoxy thinner
9.	______	Epoxy	b.	Water
10.	______	Alkyd	c.	Mineral spirits

To prime a surface means to add an undercoating that prepares the surface for painting. Not all paints will adhere well to the surface to be painted, so the surface must be changed to hold the paint.

Uses of Primer

Primer is applied to the surface of a project before the project is painted. By applying the primer before painting, the surface of the project will absorb less of the paint that is applied to the surface, resulting in less paint needed to provide a quality finish. The surface of many projects will not be compatible with the paint to be used, so primer is used to improve the surface's ability to hold paint. The addition of primer to the surface of a project creates a "tooth" to which the paint can adhere. Projects that have porous surfaces will hold paint better if a coat of primer is added before the paint to close up the pores. For metal projects, rust inhibitive primers can be used to prevent oxidation of the metal. Most primers will not withstand weather, wear, or exposure to the elements.

Selecting Primer

Several factors should be considered when selecting the right primer to be used on a project. A primer must be selected that is compatible with the surface to be painted, as well as with the paint coat that will follow. For example, an epoxy-based primer is used under an epoxy enamel paint. Follow the manufacturer's recommendation on the label of the can when selecting a primer that will match the type of paint to be used. Whether or not the surface has been previously painted, as well as the type of base used for the paint (vehicle type), will determine if some primers can be used. For example, an alkyd-based wood primer is suited only for surfaces that have not been painted. Drying time may become a factor in selecting the type of primer to use. Some primers dry in as little as one hour, whereas others may take up to 24 hours to dry. Each type of primer has special characteristics that will make them more suitable for the project than other types. The special characteristics should be carefully considered to obtain the best possible finish.

Mixing and Thinning

Most primers are ready to apply without mixing or thinning. You should read the directions on the label for specific instructions for the primer you are using. If the primer is to be used in a spray gun, it may need to be thinned to avoid clogging the spray gun. If the primer is thinned, follow the directions exactly. Too much thinner will cause the primer to lose its durability and holding power, thus reducing the life of the paint. Latex primers, since they are water-based, should be thinned with clean water (i.e., free of contaminates). Dirty water will reduce the durability of the primer. Water is also used to clean up the equipment when application is complete. Oil and alkyd-based primers are thinned with mineral spirits. Equipment should be cleaned with mineral spirits, as well. Epoxy-based primers are thinned with epoxy thinner. Most epoxy primers must be mixed with a hardener before application to promote bonding with the surface and the topcoat to be applied.

Using Primer

Primer should be applied under the proper conditions in order to achieve the best adhesion for the topcoat to be applied. Read the label for special considerations to be made when using the primer. Be sure the surface to be primed is cleaned of all dirt, grease, oil, and cleaning material residue. The temperature of the air and the surface temperature of the metal should be at least 50 degrees for proper adhesion. Avoid using primers under high humidity conditions. Due to settling during storage, the primer should be stirred well before use to restore it to the proper state. Most primers can be brushed, rolled, or sprayed onto the surface to be painted. Spraying may require thinning to avoid clogging the spray gun. Avoid over-thinning or the durability of the primer will be reduced. Since chemicals are used in the manufacture of primers, safety precautions should be observed when using them. Flammable materials should be moved out of the area and proper ventilation should be provided.

Summary

If used properly, primer will extend the life of the paint job. Proper surface preparation, combined with correct application procedures and conditions will result in a quality paint job for the project. Safety precautions and special instructions should be followed at all times when using primers to avoid injury to yourself and to provide the desired results.

Credits

Paint and Wallpaper. New York: Time-Life Books, 1977.

"Paints and Painting." VAS 3053, Urbana, IL: Vocational Agriculture Service.

TYPES OF EXTERIOR PRIMERS

Type of Surface	Vehicle Type	Dry Time	Special Characteristics
Ferrous Metal & Aluminum	Alkyd-based, rust inhibitive	Touch: 2-4 hr. Recoat: overnight	Used on new or painted surfaces; withstands climate extremes; thinning is not required; clean with mineral spirits
	Epoxy-based, rust inhibitive	Touch: 1 hr. Recoat: overnight	Used under epoxy enamel paint; must be mixed with a hardener; resistant to most solvents and cleaners; thinning is not required; clean with an epoxy thinner
	Phenolic-based alkyd, rust inhibitive	Touch: 1 hr. Recoat: 3-4 hrs.	Used on new or previously painted surfaces; can complete finish job in one day due to quick drying; no thinning required; clean with mineral spirits
Galvanized Metal	Vinyl-acrylic latex	Touch: 1 hr. Recoat: 4 hrs.	Used on painted or unpainted, rust-free surfaces; high humidity will increase drying time; can be used as a finishing paint; no thinning required; clean with water
Masonry (Concrete)	Phenolic-alkyd	Touch: 2 hrs. Recoat: 24 hours	Used on new or painted surfaces; resistant to soap and detergent; washable; one coat is sufficient; add clean sand to surfaces that are to be non-skid; thin and clean with mineral spirits
	Epoxy-modified acrylic latex	Touch: 1 hr. Recoat: overnight	Used on new or painted surfaces; first coat on new concrete should be thinned with water; no thinning is required for painted surfaces; resistant to oil, detergent, and grease; add clean sand for non-skid surfaces
	Epoxy-ester enamel	Touch: 3-6 hrs. Recoat: 24 hrs.	Used on new or painted surfaces; resistant to chemicals, acids, and grease; resists hard wear; add clean sand for non-skid surfaces; thin and clean with epoxy thinner
Wood	Alkyd-based	Touch: 6 hrs. Recoat: overnight	Works best on new surfaces; easy to apply with a brush, roller, or sprayer; good for chalky surfaces; thinning not required; clean with mineral spirits
	Alkyd-oil based	Touch: 6 hrs. Recoat: 24 hrs.	Used on painted or unpainted surfaces; uniform seal on porous surfaces; good on chalky surfaces; thinning not required; clean with mineral spirits
	Latex-based	Touch: 1 hr. Recoat: 2-4 hrs.	Used on painted or unpainted surfaces; many do not require thinning; clean with water

UNIT V - FINISHING

Lesson 3: Selecting Paint

Objective: The student will be able to select paint.

Study Questions

1. **What are the factors to consider when selecting paint?**
2. **How many coats are needed for the different types of paint?**
3. **How do you calculate the amount of paint needed?**

Reference

1. Handout
    - a) HO 3.1: Selecting Paint

UNIT V - FINISHING

Lesson 3: Selecting Paint

TEACHING PROCEDURES

A. Review

Review the previous lesson. Review the painting unit in the Agricultural Science I Core Curriculum for information on selecting paint types.

B. Motivation

The final product reflects the quality of work done on any project. The finish or covering of a project, although the final step, reflects back to the skill used throughout the construction of the project. A badly finished project reflects shabby construction or workmanship. A well-finished product reflects good craftsmanship. Show students two finished projects and let them discuss the differences between the two.

C. Assignment

D. Supervised study

E. Discussion

1. Not all types of surfaces are suited for all paints. Discuss the types of paint that can be used on the different types of projects.

What are the factors to consider when selecting paint?

a) Paint has various types of finishes.
    1) Flat
    2) Low lustre
    3) Eggshell
    4) Soft gloss
    5) Low sheen
    6) Pearl
    7) Satin
    8) Semigloss
    9) High gloss
b) The vehicle is the liquid portion (water or oil) of the paint.
    1) Water-base paints - contain water (e.g., latex)
    2) Oil-base paints - contain oil (e.g., alkyd paints)
    3) Enamel paint
    4) Epoxy paints - special adhesive and wear-resistant qualities
c) Pigment gives color and hiding power to the paint.
    1) Titanium dioxide
    2) Iron
    3) Lime
    4) Aluminum
    5) Calcium
    6) Magnesium

7) Silicon
8) Asphalt

NOTE: Lead was once used, but has been outlawed because of danger to humans and livestock.

d) Price
e) Availability of a specific primer
f) Life of the paint

2. Not all paints require the same number of coats. The condition of the surface and the presence of a previous layer of paint will affect how many coats will need to be applied. Ask students to list the number of recommended coats for the different types of paint.

How many coats are needed for the different types of paint?

a) Latex - 1 coat
b) Enamels - 2 coats
c) Epoxy esters - 1 or 2 coats

3. It is important to know the amount of paint needed to complete a project to avoid buying too much or too little paint. Discuss with students the way to determine the amount of paint needed.

How do you calculate the amount of paint needed?

a) Coverage per gallon depends on type of surface, quality of the paint, method of applying the paint, and the skill of the painter.
b) A gallon of paint normally covers 400 to 500 square feet. This information can usually be found on the label of your paint can.
c) Use same units of measure when calculating.
d) Calculate the surface area to be painted. If you are going to paint both the inside and the outside, don't forget to include this when calculating surface area.

Example 1: Walls

Step 1: Determine the dimensions of the walls to be painted. The room to be painted is 8' x 12'.

a) 2 walls are 8' x 12'
b) 2 walls are 8' x 8'

Step 2: Calculate the total square feet to be painted. Only the inside of the room will be painted.

a) 8 ft x 12 ft = 96 sq ft x 2 = 192 sq ft
b) 8 ft x 8 ft = 64 sq ft x 2 = 128 sq ft
c) 192 sq ft + 128 sq ft = 320 sq ft

Step 3: Calculate the number of gallons required to paint the walls. One gallon will cover approximately 400 sq ft.

320 sq ft + 400 sq ft = .8 gallons (About 1 gallon would be needed to apply one coat of paint.)

Example 2: Storage Box

Step 1: Refer to the bill of materials to determine the total square feet that need to be covered. The following is a bill of materials for a storage box:

a) 1 - 2" x 6" - 8 ft (96")
b) 1 - 1" x 8" - 3 ft (36")
c) 1 - 1" x 2" - 4 ft (48")

Step 2: Calculate the total square feet of wood in the project. Total square inches will need to be multiplied by 2 since both sides will be painted. Convert total square inches to square feet.

a)	6" x 96" = 576 sq in		b)	8" x 36" = 288 sq in		c)	1" x 2" = 2 sq in
	2" x 96" = 192 sq in			1" x 8" = 8 sq in			2" x 48" = 96 sq in
	2" x 6" = 12 sq in			1" x 36" = 36 sq in			1" x 48" = 48 sq in
	780 sq in			332 sq in			146 sq in

Total surface area = 780 + 324 + 146 = 1,258 sq in x 2 = 2,516 sq in + 144 = 17.47 sq ft

Step 3: Calculate the number of gallons required to paint the storage box. One gallon will cover approximately 400 sq. ft.

17.47 sq ft + 400 sq ft = .04 gallons of paint (Since 1 pint is equal to .125 gallons, less than 1 pint of paint is required to apply one coat to the project.)

F. Other activities

1. Ask students to plan a complete painting project including the color and proper paint type to be used as a final coat.

2. Take students to a local paint store and have them select, price, and order (on paper only) the paint and equipment needed to finish a project.

G. Conclusion

The selection of the proper paint is vital to the final product. An outstanding, quality finished product may sell for a better price and will look more attractive. In addition, if painted properly, the life of the equipment or item will be prolonged.

H. Competency

Select the paint to use in the finish operation.

I. Answers to Evaluation

1. Three of the following: gloss, semigloss, enamel, hot finish.
2. Oil
3. Water
4. Three of the following: finish, vehicle, pigment, price, availability, life of the paint
5. a. 8' x 8' x 2 (walls) = 128 sq ft
   8' x 10' x 2 (walls) = 160 sq ft
   128 sq ft + 160 sq ft = 288 sq ft
   b. 288 sq ft ÷ 400 sq ft = .72 gallon (Only one coat is required for adequate coverage; therefore, you would probably purchase one gallon of latex paint.)
   c. 288 sq ft ÷ 400 sq ft x 2 (coats) = 1.44 gallons (Two coats are required for adequate coverage; therefore, you would probably purchase two gallons of enamel paint.)

Name ____________________

Date ____________________

EVALUATION

Complete the following short answer questions.

1. What are three types of paint finish?

   a.

   b.

   c.

2. What type of vehicle (base) is used in alkyd paint?

3. What type of vehicle (base) is used in latex paint?

4. What are three of the factors to consider when selecting paint?

   a.

   b.

   c.

5. You need to paint the walls of a 8' x 10' room. The walls are 8' tall. The ceiling will not be painted. (Show your work below.)

   a. How many square feet will need to be painted?

   b. How much latex paint will you need to buy to paint the room adequately?

   c. How much enamel paint will you need to buy to paint the room adequately?

Factors to Consider

Not all types of paint can be used for all surfaces. Careful consideration must be made when selecting a type of paint for the project. The following factors should be considered when selecting paint for various jobs.

Finish - Several different paint finishes are available. Finish is determined by the amount of light reflected from the surface of the paint. The following are descriptive terms used by industry to designate the finish of the paint: flat, low lustre, eggshell, soft gloss, low sheen, pearl, satin, semigloss, and high gloss. High gloss paint has the shiniest surface of the paints to be discussed. Semigloss paint has a shiny surface, but is not as shiny as a high gloss enamel. A paint with a flat finish has no shine to the surface and has a chalky texture.

Vehicle - Vehicle is the liquid portion (water or oil) of the paint. Paints are characterized by the type of vehicle that is used. For example, water-based paints contain water. Latex is a type of water-based paint. Oil-based paints use oil as a vehicle, rather than water. Alkyd paints are also oil-based. Enamel paints may be either water- or oil-based. Read the label on the can to determine the type of vehicle used for the paint you are purchasing. Epoxy paints contain a resin that gives them special adhesive ability and wear resistant qualities.

Pigment - Pigment gives color and hiding power to the paint. The following are used to add color to the paint: titanium dioxide, iron, lime, aluminum, calcium, magnesium, silicon, and asphalt. Lead was once used, but has been outlawed because of danger to humans and livestock.

The life of the paint should be taken into consideration when making the selection. The life of a paint job will be based on the quality of the paint and the conditions to which the paint will be exposed. Primer is used to extend the life of the paint, as well as the project's life. The price of the primer should be taken into consideration when the paint is selected. You should evaluate where the primer will be used and if the value of the finish job will exceed the cost of the primer. Since all primers may not be readily available in your area for a specific paint, check on availability before selecting the paint and primer.

Number of Coats

Not all paints require the same number of coats. The make-up of the paint and the type of surface to be painted will determine the number of coats that are needed for the job to be performed. As a general rule, latex paints require one coat to be considered satisfactory. Enamels need two coats of paint to provide the protection to the project that is desired. Epoxy esters, like urethanes, require one or two coats, depending on the surface to be painted and the skill of the painter.

Calculating the Amount of Paint Needed

It is important to know the amount of paint needed to complete a project to avoid buying too much or too little paint. Buying too much paint will result in spending more money on the project than needed and ending with a surplus of paint that may not be sufficient to paint another project. If you buy too little paint it may be hard to match the paint when more needs to be purchased, and a delay in finishing the project will result. Coverage per gallon depends on type of surface, quality of the paint, method of applying the paint, and the skill of the painter. As a general rule, one gallon of paint normally covers 400 to 500 square feet when one coat is applied. This information can usually be found on the label of your paint can. When estimating the amount of paint needed, make sure all numbers are in the same unit of measure (e.g., sq in or sq ft). To estimate the amount of paint required, calculate the surface area to be painted. When painting both sides of the project don't forget to figure the surface area of both sides.

Height x distance around the room or building is equal to the total surface area to be painted. The following example is for a room that is 8' x 12'. The ceiling will not be painted.

Example 1:
8 ft x 12 ft = 96 sq ft x 2 walls = 192 sq ft
8 ft x 8 ft = 64 sq ft x 2 walls = 128 sq ft
192 sq ft + 128 sq ft = 320 sq ft

320 sq ft ÷ 400 sq ft = .8 gallons. If a gallon of paint will normally cover 400 square feet, then 1 gallon of paint will be needed to paint one coat.

Summary

Paint is available in many different forms. Determining the correct type of paint to apply will increase the lifespan of the paint job. It is important to be able to determine how much paint to buy based on the number of square feet to be covered and the number of coats to be applied.

Credits

Paint and Wallpaper. New York: Time-Life Books, 1977.

"Paints and Painting." VAS 3053, Urbana, IL: Vocational Agriculture Service.

Lesson 4: Painting and Cleanup

Objective: The student will be able to paint a surface using the proper method and clean up after the operation is complete.

Study Questions

1. **What safety practices should be used when applying paint?**
2. **What are the characteristics of a good paint brush?**
3. **How do you select the proper paint roller?**
4. **What procedures should be used to precondition the paint roller?**
5. **What techniques are used when painting with a roller?**
6. **How are rollers and roller pans cleaned and stored?**
7. **How are finishing products correctly stored?**
8. **How are unwanted finishing products disposed of properly?**

Reference

1. Handout
    a) HO 4.1: Painting and Cleanup

Lesson 4: Painting and Cleanup

TEACHING PROCEDURES

A. Review

Review the previous lesson on selecting paint, as well as the following topics in the painting unit of the Agricultural Science I Core Curriculum: thinning and mixing paint, paint failure, surface preparation for wood, temperature ranges for painting, brush selection, and cleaning and storing brushes.

B. Motivation

Show students examples of painting equipment (e.g., brushes, rollers, sprayers) that have not properly been cleaned. Stress the amount of work that will be required to restore the equipment to usable condition, if possible. Provide a price for each of the items used in painting to illustrate the amount of money that improper cleaning techniques can waste.

C. Assignment

D. Supervised study

E. Discussion

1. The chemicals and equipment used in painting can create a hazardous environment if safety precautions are not observed. Ask students what safety practices should be used when applying paint.

   What safety practices should be used when applying paint?

   a) Provide ventilation.
   b) Use air compressors according to manufacturer's recommendations.
   c) Use ladders safely.
   d) Use a mask or respirator when painting.

2. The proper paint brush is an important factor in providing a quality finish to the project. Discuss the characteristics of a good paint brush with the class.

   What are the characteristics of a good paint brush?

   a) Holds large quantities of paint
   b) Carries paint without dripping
   c) Prevents paint spattering
   d) Has a clean, even edge that will lay a smooth coat
   e) Soft

3. The correct procedures should be used in order to obtain a quality finished product. Ask students to describe the proper method to use when using a paint roller.

   How do you select the proper paint roller?

   Selection of proper roller and pile height
   a) Type of paint
   b) Painting surface

4. Rollers will work more easily and distribute paint more evenly if they are preconditioned before painting. Discuss the procedure to follow when preconditioning a roller.

   What procedures should be used to precondition the roller?

   a) Latex paints - Lubricate roller with plain water, then spin the roller to remove excess moisture.
   b) Oil-base paints - Lubricate with the same solvent with which the paint is thinned, then spin to remove excess solvent.
   c) Lambskin covers do not require preconditioning because of the natural oils in the fibers.

5. A smoother coat of paint can be applied if the proper techniques for using a roller are followed. Discuss these techniques with the class.

   What techniques are used when painting with a roller?

   a) Fill the paint tray only one-third full.
   b) Load the entire surface of the roller with paint. Roll it in the paint then back over the ridges in the pan until the roller is full. Do not overload the roller.
   c) Work from the top down, blending the unpainted areas into the painted areas.

6. Some expense can be saved if rollers and roller pans are cleaned up, rather than thrown away. Discuss the following ways to clean rollers and roller pans.

   How are rollers and roller pans cleaned and stored?

   a) Cleanup time is saved by lining the paint tray with aluminum foil. After painting, the foil is removed and discarded.
   b) When work is temporarily stopped, you can store the roller in an airtight plastic bag or wrapper.
   c) Cleaning rollers usually requires a large amount of water or solvent, depending on the type of paint used.
   d) It may only be practical to clean those rollers used with latex paints when cleaning can be done with warm water and detergent.

7. If an adequate amount of a product is left, it may be worthwhile to store it for later use. Ask students to discuss proper storing techniques of finishing products.

   How are finishing products correctly stored?

   a) Seal all containers.
   b) Clean the outside of the containers.
   c) Label containers.

d) Store in a warm, dry place in a non-flammable container.
e) Do not expose the container to freezing or below freezing temperatures.
f) Place it out of reach of children.
g) Storage area should be vented to the outdoors.

8. If only a small amount of a finishing product is left, it may not be worthwhile to store the remaining amount. Students should list the proper methods for disposal of unwanted products.

How do I properly dispose of unwanted finishing products?

a) All containers should be cleaned and sealed.
b) Discard paint cans and accessories in a metal container.
c) Discard painting and finishing products in an approved dump site. To prevent an explosion, never discard in a barrel were trash is burned.

F. Other activities

1. Take a trip to the local hardware store to look at various finishes available. Ask the salesperson to explain how to use the different finishes.

2. A visit to a paint manufacturing plant would be a very educational experience (e.g., Farmland Industries in Kansas City, MO).

G. Conclusion

The proper method of painting is important to ensure a quality, long-lasting finish. Proper cleanup is vital for future use of the equipment. Paint application and cleanup must be taken into consideration when planning your project, or when finishing/refinishing an older item. A good finish coat can prolong the life of an item, whereas a poorly finished product will not fulfill its useful life. Because of possible environmental hazards, it is important to properly clean, store, and dispose of painting equipment and supplies.

H. Competency

List the steps for cleanup after finishing operation is complete.

I. Answers to Evaluation

1. b
2. b
3. a
4. b
5. b

UNIT V - FINISHING

Name ____________________

Lesson 3: Painting and Cleanup

Date ____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a characteristic of a good paint brush?
   - a. Lays a smooth coat
   - b. Hard bristled
   - c. Carries paint without dripping
   - d. Holds large quantities of paint
   - e. Prevents paint spattering

2. Which of the following is a proper method for preconditioning a roller?
   - a. Soak roller in plain water for oil base paints.
   - b. Soak roller in water for latex paints.
   - c. Soak roller in paint thinner for latex paints.
   - d. Soak roller in varnish for latex paints
   - e. Rollers should not be preconditioned

3. Which of the following is not a technique used in painting with a roller?
   - a. Fill the paint tray at least 3/4 full.
   - b. Blend painted areas into unpainted areas.
   - c. Load entire surface of roller with paint.
   - d. Always work from the top down when painting.
   - e. Do not overload the paint roller.

4. What is the proper way to temporarily store a paint roller?
   - a. Lay in the paint tray, immersed in paint.
   - b. Put in an airtight plastic bag or wrapper.
   - c. Put in a bucket of cold water.
   - d. Hang by a wire attached to the ladder.
   - e. No special care is needed.

5. What is the proper way to dispose of unwanted finishing products?
   - a. Burn it.
   - b. Take it to approved dump site or chemical dump site.
   - c. Bury it.
   - d. Pour it down the sewer.
   - e. Pour it on the ground.

If the proper steps are taken when painting a project, a quality paint job should result. When painting is finished, the equipment used should be properly disposed of or cleaned. Proper cleaning will permit the equipment to be used again. Since most finishing products are highly flammable, proper cleanup and storage can prevent hazards in shop area. If the proper steps are taken when cleaning up, money will be saved in replacing equipment when it is needed again.

Safety

The chemicals used in paint and the equipment needed to paint the project require that special attention be given to providing a safe environment for yourself and those around you. When painting, proper ventilation should be provided to avoid inhaling the hazardous fumes given off by the paint. To further avoid problems from inhaling the paint, a mask or respirator should be used when painting. If the room is not properly ventilated, the chances for an explosion due to trapped fumes is greatly increased. If a paint sprayer is used, manufacturer's recommendations should be followed when using the air compressor to avoid injury to yourself or damage to the equipment. If ladders are used to reach high places in the job, extreme care should be taken not to injure yourself. Do not stand higher on the ladder than recommended by the manufacturer.

Characteristics of a Paint Brush

The proper paint brush is an important factor in providing a quality finish to the project. A good paint brush should have several basic characteristics. First of all, it should be able to hold large quantities of paint. Brushes that cannot hold a lot of paint have to be reloaded more often, thus increasing the time necessary to complete the project. You should use a brush that carries paint without dripping to avoid extra time and expense necessary to clean up after painting is finished. A good brush will result in a better paint job by preventing paint spatter. For a smoother coat an even, clean edge is desirable when selecting the paint brush. The paint brush should be soft to allow the brush to follow the shape of the project being painted.

Roller Selection

The correct procedures should be used in order to obtain a quality finished product. The selection of the proper roller and pile height is important. The roller should match the type of paint to be used, as well as the surface to be painted. If the incorrect roller is used, the quality of the paint job will be greatly reduced. Read the package the roller comes in or ask the salesperson which type of roller will work best for your situation.

Preconditioning the Roller

Most rollers will need to be preconditioned before you begin painting. Preconditioning is needed to prevent the fibers in the roller from absorbing the paint instead of allowing it to be spread on the surface. Different methods of preconditioning are needed for the different types of paints. If latex paint is to be used, the roller should be dipped in plain water then spun to remove the excess water. For oil base paints, the roller should be dipped in the same solvent in which the paint is thinned and spun to remove the excess thinner. Lambskin covers do not require preconditioning because of the natural oils in the fibers.

Techniques of Using a Roller

Several procedures should be followed in order to get the best paint job from the paint roller. The paint tray should only be filled one-third full. Overfilling makes it easier to overload the roller, as well as spill the paint. The entire surface of the roller should be loaded with paint. To completely load the roller, it should be rolled in the paint, then over the ridges in the pan until all areas on the roller are full. Do not overload the roller, or paint will drip and run more frequently. When painting with the roller, work from the top down, making sure to blend the unpainted areas into the painted areas.

Cleaning and Storing Rollers and Roller Pans

When painting is finished, the cleanup that follows will allow for extended use of equipment. Cleanup time is saved by lining the paint tray with aluminum foil. After painting, the foil is removed and discarded. When work is temporarily stopped, you can store the roller in an airtight plastic bag or wrapper. This prevents the roller from drying out, but does not require the time it takes to clean the roller. This should be done only when the roller will be used again shortly. Cleaning rollers usually requires a large amount of water or solvent, depending on the type of paint used. Many times it will be to your advantage to buy the disposable roller heads and discard them when painting is complete. Because of the cost of thinner, it may only be practical to clean those rollers used with latex paints, since they can be cleaned with warm water and detergent.

Proper Storage of Finishing Products

Painting supplies should be properly stored in order to remain in condition to be used at a later time. All containers should be sealed airtight so that the paint will not dry up. The outside of the containers should be cleaned and labeled so that it will be easy to identify the type of paint and where it was used. Store the containers in a warm, dry place in a non-flammable container. To preserve the quality of the paint, do not expose the containers to freezing or below freezing temperatures. Place the containers out of the reach of children. The storage area should be vented to the outdoors to prevent a buildup of paint fumes in an enclosed area.

Disposal

The chemicals used to manufacture paint are hazardous to the environment. Proper disposal is necessary to prevent harm to human, animal, and plant life. Several steps should be followed to decrease the effect of the chemicals on the environment. Containers should be cleaned and sealed before disposing them. Discard paint cans and accessories in a metal container. Discard painting and finishing products in an approved dump site. To prevent an explosion, never discard containers in a barrel were trash is burned.

Summary

Following the proper techniques when painting will result in a quality finish for the project. If the proper steps are taken in cleanup of equipment, many of the items used to paint the project may be used again. You should decide when purchasing the equipment needed if it will be disposed of or cleaned. Proper storage and disposal of finishing products will prevent the creation of hazardous situations.

Credits

Agricultural Science I Core Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

Paint and Wallpaper. New York: Time-Life Books, 1977.

"Paints and Painting." VAS 3053, Urbana, IL: Vocational Agriculture Service.